WAC 296-62-074 Cadmium.

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-074, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07401 Scope. This standard applies to all occupational exposures to cadmium and cadmium compounds, in all forms, and in all industries covered by the Washington Industrial Safety and Health Act, except the construction-related industries, which are covered under WAC 296-155-174.

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07401, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07403 Definitions.

(1) **"Action level"** (AL) is defined as an airborne concentration of cadmium of 2.5 micrograms per cubic meter of air (2.5 µg/m^3), calculated as an 8-hour time-weighted average (TWA).

(2) **"Authorized person"** means any person authorized by the employer and required by work duties to be present in regulated areas or any person authorized by the WISH Act or regulations issued under it to be in regulated areas.

(3) **"Director"** means the director of the department of labor and industries, or authorized representatives.

(4) **"Employee exposure"** and similar language referring to the air cadmium level to which an employee is exposed means the exposure to airborne cadmium that would occur if the employee were not using respiratory protective equipment.

(5) **"Final medical determination"** is the written medical opinion of the employee's health status by the examining physician under WAC 296-62-07423(3) through (12) or, if multiple physician review under WAC 296-62-07423(13) or the alternative physician determination under WAC 296-62-07423(14) is invoked, it is the final, written medical finding, recommendation or determination that emerges from that process.

(6) **High-efficiency particulate air (HEPA) filter** means a filter capable of trapping and retaining at least 99.97 percent of mono-dispersed particles of 0.3 micrometers in diameter.

(7) **Regulated area** means an area demarcated by the employer where an employee's exposure to airborne concentrations of cadmium exceeds, or can reasonably be expected to exceed the permissible exposure limit (PEL).

[Statutory Authority: Chapter 49.17 RCW. 93-21-075 (Order 93-06), § 296-62-07403, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07403, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07405 Permissible exposure limit (PEL). The employer shall assure that no employee is exposed to an airborne concentration of cadmium in excess of five micrograms per cubic meter of air (5 µg/m^3), calculated as an 8-hour time-weighted average exposure (TWA).

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07405, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07407 Exposure monitoring.

(1) **General.**

(a) Each employer who has a workplace or work operation covered by this section shall determine if any employee may be exposed to cadmium at or above the action level.

(b) Determinations of employee exposure shall be made from breathing zone air samples that reflect the monitored employee's regular, daily 8-hour TWA exposure to cadmium.

(c) 8-hour TWA exposures shall be determined for each employee on the basis of one or more personal breathing zone air samples reflecting full shift exposure on each shift, for each job classification, in each work area. Where several employees perform the same job tasks, in the same job classification, on the same shift, in the same work area, and the length, duration, and level of cadmium exposures are similar, an employer may sample a representative fraction of the

employees instead of all employees in order to meet this requirement. In representative sampling, the employer shall sample the employee(s) expected to have the highest cadmium exposures.

(2) **Specific.**

(a) Initial monitoring. Except as provided for in (b) and (c) of this subsection, the employer shall monitor employee exposures and shall base initial determinations on the monitoring results.

WAC 296-62-07407 (Cont.)

(b) Where the employer has monitored after September 14, 1991, under conditions that in all important aspects closely resemble those currently prevailing and where that monitoring satisfies all other requirements of this section, including the accuracy and confidence levels of subsection (6) of this section, the employer may rely on such earlier monitoring results to satisfy the requirements of WAC 296-62-07427 (2)(a).

(c) Where the employer has objective data, as defined in WAC 296-62-07427(2), demonstrating that employee exposure to cadmium will not exceed the action level under the expected conditions of processing, use, or handling, the employer may rely upon such data instead of implementing initial monitoring.

(3) **Monitoring frequency (periodic monitoring).**

(a) If the initial monitoring or periodic monitoring reveals employee exposures to be at or above the action level, the employer shall monitor at a frequency and pattern needed to represent the levels of exposure of employees and where exposures are above the PEL to assure the adequacy of respiratory selection and the effectiveness of engineering and work-practice controls. However, such exposure monitoring shall be performed at least every six months. The employer, at a minimum, shall continue these semiannual measurements unless and until the conditions set out in (b) of this subsection are met.

(b) If the initial monitoring or the periodic monitoring indicates that employee exposures are below the action level and that result is confirmed by the results of another monitoring taken at least seven days later, the employer may discontinue the monitoring for those employees whose exposures are represented by such monitoring.

(4) **Additional monitoring.** The employer also shall institute the exposure monitoring required under (2)(a) and (3) of this section whenever there has been a change in the raw materials, equipment, personnel, work-practices, or finished products that may result in additional employees being exposed to cadmium at or above the action level or in employees already exposed to cadmium at or above the action level being exposed above the PEL, or whenever the employer has any reason to suspect that any other change might result in such further exposure.

(5) **Employee notification of monitoring results.**

(a) Within fifteen working days after the receipt of the results of any monitoring performed under this section, the employer shall notify each affected employee individually in writing of the results. In addition, within the same time period the employer shall post the results of the exposure monitoring in an appropriate location that is accessible to all affected employees.

(b) Wherever monitoring results indicate that employee exposure exceeds the PEL, the employer shall include in the written notice a statement that the PEL has been exceeded and a description of the corrective action being taken by the employer to reduce employee exposure to or below the PEL.

(6) **Accuracy of measurement.** The employer shall use a method of monitoring and analysis that has an accuracy of not less than plus or minus twenty-five percent, with a confidence level of ninety-five percent, for airborne concentrations of cadmium at or above the action level, the permissible exposure limit (PEL), and the separate engineering control air limit (SECAL).

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07407, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07409 Regulated areas.

(1) **Establishment.** The employer shall establish a regulated area wherever an employee's exposure to airborne concentrations of cadmium is, or can reasonably be expected to be in excess of the permissible exposure limit (PEL).

WAC 296-62-07409 (Cont.)

(2) **Demarcation.** Regulated areas shall be demarcated from the rest of the workplace in any manner that adequately establishes and alerts employees of the boundaries of the regulated area.

(3) **Access.** Access to regulated areas shall be limited to authorized persons.

(4) **Provision of respirators.** Each person entering a regulated area shall be supplied with and required to use a respirator, selected in accordance with WAC 296-62-07413(2).

(5) **Prohibited activities.** The employer shall assure that employees do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas, carry the products associated with these activities into regulated areas, or store such products in those areas.

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07409, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07411 Methods of compliance.

(1) **Compliance hierarchy.**

(a) Except as specified in (b), (c), and (d) of this subsection, the employer shall implement engineering and work-practice controls to reduce and maintain employee exposure to cadmium at or below the PEL, except to the extent that the employer can demonstrate that such controls are not feasible.

(b) Except as specified in (c) and (d) of this subsection, in industries where a separate engineering control air limit (SECAL) has been specified for particular processes (Table 1 of this subsection), the employer shall implement engineering and work-practice controls to reduce and maintain employee exposure at or below the SECAL, except to the extent that the employer can demonstrate that such controls are not feasible.

Table 1.--Separate Engineering Control Airborne Limits (SECALs) for Processes in Selected Industries (SECALs)

Process	SECAL	(µg/m^3)
Nickel Cadmium battery	Plate making, plate preparation All other processes	50 15
Zinc/Cadmium refining	Cadmium refining, casting, melting. oxide production, sinter plant	50
Pigment manufacture	Calcine, crushing, milling, blending All other processes	50 15
Stabilizers	Cadmium oxice charging, crushing, drying, blending	50
Lead smelting+	Sinter plant, blast furnace, baghouse, yard area	50
Plating*	Mechanical plating	15

* Processes in these industries that are not specified in this table must achieve the PEL using engineering controls and work-practices as required in (a) of this subsection.

(c) The requirement to implement engineering and work-practice controls to achieve the PEL or, where applicable, the SECAL does not apply where the employer demonstrates the following:

(i) The employee is only intermittently exposed; and

(ii) The employee is not exposed above the PEL on thirty or more days per year (twelve consecutive months).

WAC 296-62-07411 (Cont.)

(d) Wherever engineering and work-practice controls are required and are not sufficient to reduce employee exposure to or below the PEL or, where applicable, the SECAL, the employer nonetheless shall implement such controls to reduce exposures to the lowest levels achievable. The employer shall supplement such controls with respiratory protection that complies with the requirements of WAC 296-62-07413 and the PEL.

(e) The employer shall not use employee rotation as a method of compliance.

(2) **Compliance program.**

(a) Where the PEL is exceeded, the employer shall establish and implement a written compliance program to reduce employee exposure to or below the PEL by means of engineering and work-practice controls, as required by subsection (1) of this section. To the extent that engineering and work-practice controls cannot reduce exposures to or below the PEL, the employer shall include in the written compliance program the use of appropriate respiratory protection to achieve compliance with the PEL.

(b) Written compliance programs shall include at least the following:

(i) A description of each operation in which cadmium is emitted; e.g., machinery used, material processed, controls in place, crew size, employee job responsibilities, operating procedures, and maintenance practices;

(ii) A description of the specific means that will be employed to achieve compliance, including engineering plans and studies used to determine methods selected for controlling exposure to cadmium, as well as, where necessary, the use of appropriate respiratory protection to achieve the PEL;

(iii) A report of the technology considered in meeting the PEL;

(iv) Air monitoring data that document the sources of cadmium emissions;

(v) A detailed schedule for implementation of the program, including documentation such as copies of purchase orders for equipment, construction contracts, etc.;

(vi) A work-practice program that includes items required under WAC 296-62-07415, 296-62-07417, and 296-62-07419;

(vii) A written plan for emergency situations, as specified in WAC 296-62-07415; and

(viii) Other relevant information.

(c) The written compliance programs shall be reviewed and updated at least annually, or more often if necessary, to reflect significant changes in the employer's compliance status.

(d) Written compliance programs shall be provided upon request for examination and copying to affected employees, designated employee representatives, and the director.

WAC 296-62-07411 (Cont.)

(3) **Mechanical ventilation.**

(a) When ventilation is used to control exposure, measurements that demonstrate the effectiveness of the system in controlling exposure, such as capture velocity, duct velocity, or static pressure shall be made as necessary to maintain its effectiveness.

(b) Measurements of the system's effectiveness in controlling exposure shall be made as necessary within five working days of any change in production, process, or control that might result in a significant increase in employee exposure to cadmium.

(c) Recirculation of air. If air from exhaust ventilation is recirculated into the workplace, the system shall have a high efficiency filter and be monitored to assure effectiveness.

(d) Procedures shall be developed and implemented to minimize employee exposure to cadmium when maintenance of ventilation systems and changing of filters is being conducted.

[Statutory Authority: Chapter 49.17 RCW. 93-21-075 (Order 93-06), § 296-62-07411, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07411, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07413 Respirator protection.

(1) **General.** For employees who use respirators required by this section, the employer must provide respirators that comply with the requirements of this subsection. Respirators must be used during:

(a) Periods necessary to install or implement feasible engineering and work-practice controls when employee exposure levels exceed the PEL;

(b) Maintenance and repair activities, and brief or intermittent operations, where employee exposures exceed the PEL and engineering and work-practice controls are not feasible or are not required;

(c) Activities in regulated areas as specified in WAC 296-62-07409;

(d) Work operations for which the employer has implemented all feasible engineering and work-practice controls and such controls are not sufficient to reduce employee exposures to or below the PEL;

(e) Work operations for which an employee who is exposed to cadmium at or above the action level, and the employee requests a respirator;

(f) Work operations for which an employee is exposed above the PEL and engineering controls are not required by WAC 296-62-07411(1)(b); and

(g) Emergencies.

(2) **Respirator program.**

(a) The employer must implement a respiratory protection program as required by chapter 296-842 WAC, except WAC 296-842-13005 and 296-842-14005.

(b) No employees must use a respirator if, based on their recent medical examination, the examining physician determines that they will be unable to continue to function normally while using a respirator. If the physician determines that the employee must be limited in, or removed from, their current job because of their inability to use a respirator, the limitation or removal must be in accordance with WAC 296-62-07423(11) and (12).

WAC 296-62-07413 (Cont.)

(c) If an employee has breathing difficulty during fit testing or respirator use, the employer must provide the employee with a medical examination as required by WAC 296-62-07423(6)(b) to determine if the employee can use a respirator while performing the required duties.

(3) Respirator selection.

(a) The employer must select the appropriate respirator from Table 2 of this section.

Table 2.--Respiratory Protection for Cadmium	
Airborne concentration	**Required respirator type[b]**
10 x or less	A half mask, air-purifying respirator equipped with a HEPA[c] filter.[d]
25 x or less	A powered air-purifying respirator ("PAPR") with a loose-fitting hood or helmet equipped with a HEPA filter, or a supplied-air respirator with a loose-fitting hood or helmet facepiece operated in the continuous flow mode.
50 x or less	A full facepiece air-purifying respirator equipped with a HEPA filter, or a powered air-purifying respirator with a tight-fitting half mask equipped with a HEPA filter, or a supplied air respirator with a tight-fitting half mask operated in the continuous flow mode.
250 x or less	A powered air-purifying respirator with a tight-fitting full facepiece equipped with a HEPA filter, or a supplied-air respirator with a tight-fitting full facepiece operated in the continuous flow mode.
1000 x or less	A supplied-air respirator with half mask or full facepiece operated in the pressure demand or other positive pressure mode.
>1000 x or unknown concentrations	A self-contained breathing apparatus with a full facepiece operated in the pressure demand or other positive pressure mode, or a supplied-air respirator with a full facepiece operated in the pressure demand or other positive pressure mode and equipped with an auxiliary escape type self-contained breathing apparatus operated in the pressure demand mode.
Fire fighting	A self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

[a] Concentrations expressed as multiple of the PEL.
[b] Respirators assigned for higher environmental concentrations may be used at lower exposure levels. Quantitative fit testing is required for all tight-fitting air purifying respirators where airborne concentration of cadmium exceeds 10 times the TWA PEL (10x5 $\mu g/m^3$ = 50 $\mu g/m^3$). A full facepiece respirator is required when eye irritation is experienced.
[c] HEPA means High Efficiency Particulate Air.
[d] Fit testing, qualitative or quantitative, is required.

SOURCE: Respiratory Decision Logic, NIOSH, 1987.

(b) The employer must provide an employee with a powered, air-purifying respirator (PAPR) instead of a negative-pressure respirator when an employee who is entitled to a respirator chooses to use this type of respirator, and such a respirator provides adequate protection to the employee.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 05-03-093 (Order 04-41), § 296-62-07413, filed 01/18/05, effective 03/01/05. Statutory Authority: RCW 49.17.010, .040, .050. 99-10 (Order 98-10) § § 296-62-07413, filed 05/04/99, effective 09/01/99. Statutory Authority: Chapter 49.17 RCW. 93-21-075 (Order 93-06), § 296-62-07413, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07413, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07415 Emergency situations. The employer shall develop and implement a written plan for dealing with emergency situations involving substantial releases of airborne cadmium. The plan shall include provisions for the use of appropriate respirators and personal protective equipment. In addition, employees not essential to correcting the emergency situation shall be restricted from the area and normal operations halted in that area until the emergency is abated.
[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07415, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07417 Protective work clothing and equipment.

(1) **Provision and use.** If an employee is exposed to airborne cadmium above the PEL or where skin or eye irritation is associated with cadmium exposure at any level, the employer shall provide at no cost to the employee, and assure that the employee uses, appropriate protective work clothing and equipment that prevents contamination of the employee and the employee's garments. Protective work clothing and equipment includes, but is not limited to:

(a) Coveralls or similar full-body work clothing;

(b) Gloves, head coverings, and boots or foot coverings; and

(c) Face shields, vented goggles, or other appropriate protective equipment that complies with WAC 296-800-160.

(2) **Removal and storage.**

(a) The employer shall assure that employees remove all protective clothing and equipment contaminated with cadmium at the completion of the work shift and do so only in change rooms provided in accordance with WAC 296-62-07419(1).

(b) The employer shall assure that no employee takes cadmium-contaminated protective clothing or equipment from the workplace, except for employees authorized to do so for purposes of laundering, cleaning, maintaining, or disposing of cadmium contaminated protective clothing and equipment at an appropriate location or facility away from the workplace.

(c) The employer shall assure that contaminated protective clothing and equipment, when removed for laundering, cleaning, maintenance, or disposal, is placed and stored in sealed, impermeable bags or other closed, impermeable containers that are designed to prevent dispersion of cadmium dust.

(d) The employer shall assure that bags or containers of contaminated protective clothing and equipment that are to be taken out of the change rooms or the workplace for laundering, cleaning, maintenance, or disposal shall bear labels in accordance with WAC 296-62-07425(3).

(3) **Cleaning, replacement, and disposal.**

(a) The employer shall provide the protective clothing and equipment required by subsection (1) of this section in a clean and dry condition as often as necessary to maintain its effectiveness, but in any event at least weekly. The employer is responsible for cleaning and laundering the protective clothing and equipment required by this paragraph to maintain its effectiveness and is also responsible for disposing of such clothing and equipment.

(b) The employer also is responsible for repairing or replacing required protective clothing and equipment as needed to maintain its effectiveness. When rips or tears are detected while an employee is working they shall be immediately mended, or the worksuit shall be immediately replaced.

WAC 296-62-07417 (Cont.)

(c) The employer shall prohibit the removal of cadmium from protective clothing and equipment by blowing, shaking, or any other means that disperses cadmium into the air.

(d) The employer shall assure that any laundering of contaminated clothing or cleaning of contaminated equipment in the workplace is done in a manner that prevents the release of airborne cadmium in excess of the permissible exposure limit prescribed in WAC 296-62-07405.

(e) The employer shall inform any person who launders or cleans protective clothing or equipment contaminated with cadmium of the potentially harmful effects of exposure to cadmium and that the clothing and equipment should be laundered or cleaned in a manner to effectively prevent the release of airborne cadmium in excess of the PEL.

[Statutory Authority: RCW 49.17.010, .040, .050. 01-11-038 (Order 99-36), § 296-62-07417, filed 05/09/01, effective 09/01/01. Statutory Authority: Chapter 49.17 RCW. 94-20-057 (Order 94-16), § 296-62-07417, filed 9/30/94, effective 11/20/94; 93-21-075 (Order 93-06), § 296-62-07417, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07417, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07419 Hygiene areas and practices.

(1) **General.** For employees whose airborne exposure to cadmium is above the PEL, the employer shall provide clean change rooms, handwashing facilities, showers, and lunchroom facilities that comply with WAC 296-800-230.

(2) **Change rooms.** The employer shall assure that change rooms are equipped with separate storage facilities for street clothes and for protective clothing and equipment, which are designed to prevent dispersion of cadmium and contamination of the employee's street clothes.

(3) **Showers and handwashing facilities.**

(a) The employer shall assure that employees who are exposed to cadmium above the PEL shower during the end of the work shift.

(b) The employer shall assure that employees whose airborne exposure to cadmium is above the PEL wash their hands and faces prior to eating, drinking, smoking, chewing tobacco or gum, or applying cosmetics.

(4) **Lunchroom facilities.**

(a) The employer shall assure that the lunchroom facilities are readily accessible to employees, that tables for eating are maintained free of cadmium, and that no employee in a lunchroom facility is exposed at any time to cadmium at or above a concentration of 2.5 $\mu g/m^3$.

(b) The employer shall assure that employees do not enter lunchroom facilities with protective work clothing or equipment unless surface cadmium has been removed from the clothing and equipment by HEPA vacuuming or some other method that removes cadmium dust without dispersing it.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 03-18-090 (Order 03-15), § 296-62-07419, filed 09/02/03, effective 11/01/03. Statutory Authority: RCW 49.17.010, .040, .050. 01-11-038 (Order 99-36), § 296-62-07419, filed 05/09/01, effective 09/01/01. Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07419, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07421 Housekeeping.

(1) All surfaces shall be maintained as free as practicable of accumulations of cadmium.

(2) All spills and sudden releases of material containing cadmium shall be cleaned up as soon as possible.

(3) Surfaces contaminated with cadmium shall, wherever possible, be cleaned by vacuuming or other methods that minimize the likelihood of cadmium becoming airborne.

WAC 296-62-07421 (Cont.)

(4) HEPA-filtered vacuuming equipment or equally effective filtration methods shall be used for vacuuming. The equipment shall be used and emptied in a manner that minimizes the reentry of cadmium into the workplace.

(5) Shoveling, dry or wet sweeping, and brushing may be used only where vacuuming or other methods that minimize the likelihood of cadmium becoming airborne have been tried and found not to be effective.

(6) Compressed air shall not be used to remove cadmium from any surface unless the compressed air is used in conjunction with a ventilation system designed to capture the dust cloud created by the compressed air.

(7) Waste, scrap, debris, bags, containers, personal protective equipment, and clothing contaminated with cadmium and consigned for disposal must be collected and disposed of in sealed impermeable bags or other closed, impermeable containers. These bags and containers must be labeled in accordance with WAC 296-62-07425(3).

[Statutory Authority: RCW 49.17.010, .040, .050. 02-12-098 (Order 00-20), § 296-62-07421, filed 06/05/02, effective 08/01/02. Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07421, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07423 Medical surveillance.

(1) **General.**

(a) Scope.

(i) Currently exposed. The employer shall institute a medical surveillance program for all employees who are or may be exposed to cadmium at or above the action level unless the employer demonstrates that the employee is not, and will not be, exposed at or above the action level on thirty or more days per year (twelve consecutive months); and

(ii) Previously exposed. The employer shall also institute a medical surveillance program for all employees who prior to the effective date of this section might previously have been exposed to cadmium at or above the action level by the employer, unless the employer demonstrates that the employee did not prior to the effective date of this section work for the employer in jobs with exposure to cadmium for an aggregated total of more than sixty months.

(b) To determine an employee's fitness for using a respirator, the employer shall provide the limited medical examination specified in subsection (6) of this section.

(c) The employer shall assure that all medical examinations and procedures required by this standard are performed by or under the supervision of a licensed physician, who has read and is familiar with the health effects WAC 296-62-07441, Appendix A, the regulatory text of this section, the protocol for sample handling and laboratory selection in WAC 296-62-07451, Appendix F and the questionnaire of WAC 296-62-07447, Appendix D. These examinations and procedures shall be provided without cost to the employee and at a time and place that is reasonable and convenient to employees.

(d) The employer shall assure that the collecting and handling of biological samples of cadmium in urine (CdU), cadmium in blood (CdB), and beta-2 microglobulin in urine (ß2-M) taken from employees under this section is done in a manner that assures their reliability and that analysis of biological samples of cadmium in urine (CdU), cadmium in blood (CdB), and beta-2 microglobulin in urine (ß2-M) taken from employees under this section is performed in laboratories with demonstrated proficiency for that particular analyte. (See WAC 296-62-07451, Appendix F.)

WAC 296-62-07423 (Cont.)

(2) **Initial examination.**

(a) The employer shall provide an initial (preplacement) examination to all employees covered by the medical surveillance program required in subsection (1)(a) of this section. The examination shall be provided to those employees within thirty days after initial assignment to a job with exposure to cadmium or no later than ninety days after the effective date of this section, whichever date is later.

(b) The initial (preplacement) medical examination shall include:

(i) A detailed medical and work history, with emphasis on: Past, present, and anticipated future exposure to cadmium; any history of renal, cardiovascular, respiratory, hematopoietic, reproductive, and/or musculo-skeletal system dysfunction; current usage of medication with potential nephrotoxic side-effects; and smoking history and current status; and

(ii) Biological monitoring that includes the following tests:

(A) Cadmium in urine (CdU), standardized to grams of creatinine (g/Cr);

(B) Beta-2 microglobulin in urine (ß2-M), standardized to grams of creatinine (g/Cr), with pH specified, as described in WAC 296-62-07451, Appendix F; and

(C) Cadmium in blood (CdB), standardized to liters of whole blood (lwb).

(c) Recent examination: An initial examination is not required to be provided if adequate records show that the employee has been examined in accordance with the requirements of (b) of this subsection within the past twelve months. In that case, such records shall be maintained as part of the employee's medical record and the prior exam shall be treated as if it were an initial examination for the purposes of subsections (3) and (4) of this section.

(3) **Actions triggered by initial biological monitoring:**

(a) If the results of the initial biological monitoring tests show the employee's CdU level to be at or below 3 µg/g Cr, ß2-M level to be at or below 300 µg/g Cr and CdB level to be at or below 5 µg/lwb, then:

(i) For currently exposed employees, who are subject to medical surveillance under subsection (1)(a)(i) of this section, the employer shall provide the minimum level of periodic medical surveillance in accordance with the requirements in subsection (4)(a) of this section; and

(ii) For previously exposed employees, who are subject to medical surveillance under subsection (1)(a)(ii) of this section, the employer shall provide biological monitoring for CdU, ß2-M, and CdB one year after the initial biological monitoring and then the employer shall comply with the requirements of subsection (4)(e) of this section.

(b) For all employees who are subject to medical surveillance under subsection (1)(a) of this section, if the results of the initial biological monitoring tests show the level of CdU to exceed 3 µg/g Cr, the level of ß2-M to exceed 300 µg/g Cr, or the level of CdB to exceed 5 µg/lwb, the employer shall:

(i) Within two weeks after receipt of biological monitoring results, reassess the employee's occupational exposure to cadmium as follows:

WAC 296-62-07423 (Cont.)

(A) Reassess the employee's work-practices and personal hygiene;

(B) Reevaluate the employee's respirator use, if any, and the respirator program;

(C) Review the hygiene facilities;

(D) Reevaluate the maintenance and effectiveness of the relevant engineering controls;

(E) Assess the employee's smoking history and status;

(ii) Within thirty days after the exposure reassessment, specified in (b)(i) of this subsection, take reasonable steps to correct any deficiencies found in the reassessment that may be responsible for the employee's excess exposure to cadmium; and,

(iii) Within ninety days after receipt of biological monitoring results, provide a full medical examination to the employee in accordance with the requirements of WAC 296-62-07423 (4)(b). After completing the medical examination, the examining physician shall determine in a written medical opinion whether to medically remove the employee. If the physician determines that medical removal is not necessary, then until the employee's CdU level falls to or below 3 µg/g Cr, ß2-M level falls to or below 300 µg/g Cr and CdB level falls to or below 5 µg/lwb, the employer shall:

(A) Provide biological monitoring in accordance with subsection (2)(b)(ii) of this section on a semiannual basis; and

(B) Provide annual medical examinations in accordance with subsection (4)(b) of this section.

(c) For all employees who are subject to medical surveillance under subsection (1)(a) of this section, if the results of the initial biological monitoring tests show the level of CdU to be in excess of 15 µg/g Cr, or the level of CdB to be in excess of 15 µg/lwb, or the level of ß2-M to be in excess of 1,500 µg/g Cr, the employer shall comply with the requirements of (b)(i) and (ii) of this subsection. Within ninety days after receipt of biological monitoring results, the employer shall provide a full medical examination to the employee in accordance with the requirements of subsection (4)(b) of this section.

After completing the medical examination, the examining physician shall determine in a written medical opinion whether to medically remove the employee. However, if the initial biological monitoring results and the biological monitoring results obtained during the medical examination both show that: CdU exceeds 15 µg/g Cr; or CdB exceeds 15 µg/lwb; or ß2-M exceeds 1500 µg/g Cr, and in addition CdU exceeds 3 µg/g Cr or CdB exceeds 5 µg/liter of whole blood, then the physician shall medically remove the employee from exposure to cadmium at or above the action level. If the second set of biological monitoring results obtained during the medical examination does not show that a mandatory removal trigger level has been exceeded, then the employee is not required to be removed by the mandatory provisions of this section. If the employee is not required to be removed by the mandatory provisions of this section or by the physician's determination, then until the employee's CdU level falls to or below 3 µg/g Cr, ß2-M level falls to or below 300 µg/g Cr and CdB level falls to or below 5 µg/lwb, the employer shall:

(i) Periodically reassess the employee's occupational exposure to cadmium;

(ii) Provide biological monitoring in accordance with subsection (2)(b)(ii) of this section on a quarterly basis; and

WAC 296-62-07423 (Cont.)

(iii) Provide semiannual medical examinations in accordance with subsection (4)(b) of this section.

(d) For all employees to whom medical surveillance is provided, beginning on January 1, 1999, and in lieu of (a) through (c) of this subsection:

(i) If the results of the initial biological monitoring tests show the employee's CdU level to be at or below 3 µg/g Cr, ß2-M level to be at or below 300 µg/g Cr and CdB level to be at or below 5 µg/lwb, then for currently exposed employees, the employer shall comply with the requirements of (a)(i) of this subsection and for previously exposed employees, the employer shall comply with the requirements of (a)(ii) of this subsection;

(ii) If the results of the initial biological monitoring tests show the level of CdU to exceed 3 µg/g Cr, the level of ß2-M to exceed 300 µg/g Cr, or the level of CdB to exceed 5 µg/lwb, the employer shall comply with the requirements of (b)(i) through (iii) of this subsection; and

(iii) If the results of the initial biological monitoring tests show the level of CdU to be in excess of 7 µg/g Cr, or the level of CdB to be in excess of 10 µg/lwb, or the level of ß2-M to be in excess of 750 µg/g Cr, the employer shall: Comply with the requirements of (b)(i) through (ii) of this subsection; and, within ninety days after receipt of biological monitoring results, provide a full medical examination to the employee in accordance with the requirements of subsection (4)(b) of this section. After completing the medical examination, the examining physician shall determine in a written medical opinion whether to medically remove the employee. However, if the initial biological monitoring results and the biological monitoring results obtained during the medical examination both show that: CdU exceeds 7 µg/g Cr; or CdB exceeds 10 µg/lwb; or ß2-M exceeds 750 µg/g Cr, and in addition CdU exceeds 3 µg/g Cr or CdB exceeds 5 µg/liter of whole blood, then the physician shall medically remove the employee from exposure to cadmium at or above the action level. If the second set of biological monitoring results obtained during the medical examination does not show that a mandatory removal trigger level has been exceeded, then the employee is not required to be removed by the mandatory provisions of this section. If the employee is not required to be removed by the mandatory provisions of this section or by the physician's determination, then until the employee's CdU level falls to or below 3 µg/g Cr, ß2-M level falls to or below 300 µg/g Cr and CdB level falls to or below 5 µg/lwb, the employer shall: periodically reassess the employee's occupational exposure to cadmium; provide biological monitoring in accordance with subsection (2)(b)(ii) of this section on a quarterly basis; and provide semiannual medical examinations in accordance with subsection (4)(b) of this section.

(4) **Periodic medical surveillance.**

(a) For each employee who is covered under subsection (1)(a)(i) of this section, the employer shall provide at least the minimum level of periodic medical surveillance, which consists of periodic medical examinations and periodic biological monitoring. A periodic medical examination shall be provided within one year after the initial examination required by subsection (2) of this section and thereafter at least biennially. Biological sampling shall be provided at least annually, either as part of a periodic medical examination or separately as periodic biological monitoring.

(b) The periodic medical examination shall include:

WAC 296-62-07423 (Cont.)

(i) A detailed medical and work history, or update thereof, with emphasis on: Past, present and anticipated future exposure to cadmium; smoking history and current status; reproductive history; current use of medications with potential nephrotoxic side-effects; any history of renal, cardiovascular, respiratory, hematopoietic, and/or musculo-skeletal system dysfunction; and as part of the medical and work history, for employees who wear respirators, questions 3-11 and 25-32 in WAC 296-62-07447, Appendix D;

(ii) A complete physical examination with emphasis on: Blood pressure, the respiratory system, and the urinary system;

(iii) A 14 inch by 17 inch, or a reasonably standard sized posterior-anterior chest X-ray (after the initial X-ray, the frequency of chest X-rays is to be determined by the examining physician);

(iv) Pulmonary function tests, including forced vital capacity (FVC) and forced expiratory volume at 1 second (FEV_1);

(v) Biological monitoring, as required in subsection (2)(b)(ii) of this section;

(vi) Blood analysis, in addition to the analysis required under this section, including blood urea nitrogen, complete blood count, and serum creatinine;

(vii) Urinalysis, in addition to the analysis required under subsection (2)(b)(ii) of this section, including the determination of albumin, glucose, and total and low molecular weight proteins;

(viii) For males over forty years old, prostate palpation, or other at least as effective diagnostic test(s); and

(ix) Any additional tests deemed appropriate by the examining physician.

(c) Periodic biological monitoring shall be provided in accordance with subsection (2)(b)(ii) of this section.

(d) If the results of periodic biological monitoring or the results of biological monitoring performed as part of the periodic medical examination show the level of the employee's CdU, ß2-M, or CdB to be in excess of the levels specified in subsection (3)(b) or (c) of this section; or, beginning on January 1, 1999, in excess of the levels specified in subsection (3)(b) or (d) of this section, the employer shall take the appropriate actions specified in subsection (3)(b) through (d) of this section.

(e) For previously exposed employees under subsection (1)(a)(ii) of this section:

(i) If the employee's levels of CdU did not exceed 3 µg/g Cr, CdB did not exceed 5 µg/lwb, and ß2-M did not exceed 300 µg/g Cr in the initial biological monitoring tests, and if the results of the follow-up biological monitoring required by subsection (3)(a)(ii) of this section one year after the initial examination confirm the previous results, the employer may discontinue all periodic medical surveillance for that employee.

(ii) If the initial biological monitoring results for CdU, CdB, or ß2-M were in excess of the levels specified in subsection (3)(a) of this section, but subsequent biological monitoring results required by subsection (3)(b) through (e) of this section show that the employee's CdU levels no longer exceed 3 µg/g Cr, CdB levels no longer exceed 5 µg/lwb, and

ß2-M levels no longer exceed 300 µg/g Cr, the employer shall provide biological monitoring for CdU, CdB, and ß2-M one year after these most recent biological monitoring results. If the results of the follow-up biological monitoring, specified in this section, confirm the previous results, the employer may discontinue all periodic medical surveillance for that employee.

(iii) However, if the results of the follow-up tests specified in (e)(i) or (ii) of this subsection indicate that the level of the employee's CdU, ß2-M, or CdB exceeds these same levels, the employer is required to provide annual medical examinations in accordance with the provisions of (b) of this subsection until the results of biological monitoring are consistently below these levels or the examining physician determines in a written medical opinion that further medical surveillance is not required to protect the employee's health.

(f) A routine, biennial medical examination is not required to be provided in accordance with subsections (3)(a) and (4) of this section if adequate medical records show that the employee has been examined in accordance with the requirements of (b) of this subsection within the past twelve months. In that case, such records shall be maintained by the employer as part of the employee's medical record, and the next routine, periodic medical examination shall be made available to the employee within two years of the previous examination.

(5) **Actions triggered by medical examinations.** If the results of a medical examination carried out in accordance with this section indicate any laboratory or clinical finding consistent with cadmium toxicity that does not require employer action under subsections (2), (3), or (4) of this section, the employer, within thirty days, shall reassess the employee's occupational exposure to cadmium and take the following corrective action until the physician determines they are no longer necessary:

(a) Periodically reassess: The employee's work-practices and personal hygiene; the employee's respirator use, if any; the employee's smoking history and status; the respiratory protection program; the hygiene facilities; and the maintenance and effectiveness of the relevant engineering controls;

(b) Within thirty days after the reassessment, take all reasonable steps to correct the deficiencies found in the reassessment that may be responsible for the employee's excess exposure to cadmium;

(c) Provide semiannual medical reexaminations to evaluate the abnormal clinical sign(s) of cadmium toxicity until the results are normal or the employee is medically removed; and

(d) Where the results of tests for total proteins in urine are abnormal, provide a more detailed medical evaluation of the toxic effects of cadmium on the employee's renal system.

(6) **Examination for respirator use.**

(a) To determine an employee's fitness for respirator use, the employer shall provide a medical examination that includes the elements specified in (a)(i) through (iv) of this subsection. This examination shall be provided prior to the employee's being assigned to a job that requires the use of a respirator or no later than ninety days after this section goes into effect, whichever date is later, to any employee without a medical examination within the preceding twelve months that satisfies the requirements of this paragraph.

(i) A detailed medical and work history, or update thereof, with emphasis on: Past exposure to cadmium; smoking history and current status; any history of renal, cardiovascular, respiratory, hematopoietic, and/or musculoskeletal system dysfunction; a description of the job for which the respirator is required; and questions 3 through 11 and 25 through 32 in WAC 296-62-07447, Appendix D;

WAC 296-62-07423 (Cont.)

(ii) A blood pressure test;

(iii) Biological monitoring of the employee's levels of CdU, CdB and ß2-M in accordance with the requirements of subsection (2)(b)(ii) of this section, unless such results already have been obtained within the previous twelve months; and

(iv) Any other test or procedure that the examining physician deems appropriate.

(b) After reviewing all the information obtained from the medical examination required in (a) of this subsection, the physician shall determine whether the employee is fit to wear a respirator.

(c) Whenever an employee has exhibited difficulty in breathing during a respirator fit test or during use of a respirator, the employer, as soon as possible, shall provide the employee with a periodic medical examination in accordance with subsection (4)(b) of this section to determine the employee's fitness to wear a respirator.

(d) Where the results of the examination required under (a), (b), or (c) of this subsection are abnormal, medical limitation or prohibition of respirator use shall be considered. If the employee is allowed to wear a respirator, the employee's ability to continue to do so shall be periodically evaluated by a physician.

(7) **Emergency examinations.**

(a) In addition to the medical surveillance required in subsections (2) through (6) of this section, the employer shall provide a medical examination as soon as possible to any employee who may have been acutely exposed to cadmium because of an emergency.

(b) The examination shall include the requirements of subsection (4)(b) of this section, with emphasis on the respiratory system, other organ systems considered appropriate by the examining physician, and symptoms of acute overexposure, as identified in WAC 296-62-07441 (2)(b)(i) through (ii) and (4), Appendix A.

(8) **Termination of employment examination.**

(a) At termination of employment, the employer shall provide a medical examination in accordance with subsection (4)(b) of this section, including a chest x-ray, to any employee to whom at any prior time the employer was required to provide medical surveillance under subsection (1)(a) or (7) of this section. However, if the last examination satisfied the requirements of subsection (4)(b) of this section and was less than six months prior to the date of termination, no further examination is required unless otherwise specified in subsection (3) or (5) of this section;

(b) However, for employees covered by subsection (1)(a)(ii) of this section, if the employer has discontinued all periodic medical surveillance under subsection (4)(e) of this section, no termination of employment medical examination is required.

(9) **Information provided to the physician.** The employer shall provide the following information to the examining physician:

(a) A copy of this standard and appendices;

(b) A description of the affected employee's former, current, and anticipated duties as they relate to the employee's occupational exposure to cadmium;

WAC 296-62-07423 (Cont.)

(c) The employee's former, current, and anticipated future levels of occupational exposure to cadmium;

(d) A description of any personal protective equipment, including respirators, used or to be used by the employee, including when and for how long the employee has used that equipment; and

(e) Relevant results of previous biological monitoring and medical examinations.

(10) **Physician's written medical opinion.**

(a) The employer shall promptly obtain a written, signed medical opinion from the examining physician for each medical examination performed on each employee. This written opinion shall contain:

(i) The physician's diagnosis for the employee;

(ii) The physician's opinion as to whether the employee has any detected medical condition(s) that would place the employee at increased risk of material impairment to health from further exposure to cadmium, including any indications of potential cadmium toxicity;

(iii) The results of any biological or other testing or related evaluations that directly assess the employee's absorption of cadmium;

(iv) Any recommended removal from, or limitation on the activities or duties of the employee or on the employee's use of personal protective equipment, such as respirators;

(v) A statement that the physician has clearly and carefully explained to the employee the results of the medical examination, including all biological monitoring results and any medical conditions related to cadmium exposure that require further evaluation or treatment, and any limitation on the employee's diet or use of medications.

(b) The employer promptly shall obtain a copy of the results of any biological monitoring provided by an employer to an employee independently of a medical examination under subsections (2) and (4) of this section, and, in lieu of a written medical opinion, an explanation sheet explaining those results.

(c) The employer shall instruct the physician not to reveal orally or in the written medical opinion given to the employer specific findings or diagnoses unrelated to occupational exposure to cadmium.

(11) **Medical removal protection (MRP).**

(a) General.

(i) The employer shall temporarily remove an employee from work where there is excess exposure to cadmium on each occasion that medical removal is required under subsection (3), (4), or (6) of this section and on each occasion that a physician determines in a written medical opinion that the employee should be removed from such exposure. The physician's determination may be based on biological monitoring results, inability to wear a respirator, evidence of illness, other signs or symptoms of cadmium-related dysfunction or disease, or any other reason deemed medically sufficient by the physician.

(ii) The employer shall medically remove an employee in accordance with this subsection regardless of whether at the time of removal a job is available into which the removed employee may be transferred.

WAC 296-62-07423 (Cont.)

(iii) Whenever an employee is medically removed under this subsection, the employer shall transfer the removed employee to a job where the exposure to cadmium is within the permissible levels specified in that subsection as soon as one becomes available.

(iv) For any employee who is medically removed under the provisions of (a) of this subsection, the employer shall provide follow-up biological monitoring in accordance with subsection (2)(b)(ii) of this section at least every three months and follow-up medical examinations semiannually at least every six months until in a written medical opinion the examining physician determines that either the employee may be returned to his/her former job status as specified under (d) through (e) of this subsection or the employee must be permanently removed from excess cadmium exposure.

(v) The employer may not return an employee who has been medically removed for any reason to his/her former job status until a physician determines in a written medical opinion that continued medical removal is no longer necessary to protect the employee's health.

(b) Where an employee is found unfit to wear a respirator under subsection (6)(b) of this section, the employer shall remove the employee from work where exposure to cadmium is above the PEL.

(c) Where removal is based on any reason other than the employee's inability to wear a respirator, the employer shall remove the employee from work where exposure to cadmium is at or above the action level.

(d) Except as specified in (e) of this subsection, no employee who was removed because his/her level of CdU, CdB and/or ß2-M exceeded the medical removal trigger levels in subsection (3) or (4) of this section may be returned to work with exposure to cadmium at or above the action level until the employee's levels of CdU fall to or below 3 µg/g Cr, CdB falls to or below 5 µg/lwb, and ß2-M falls to or below 300 µg/g Cr.

(e) However, when in the examining physician's opinion continued exposure to cadmium will not pose an increased risk to the employee's health and there are special circumstances that make continued medical removal an inappropriate remedy, the physician shall fully discuss these matters with the employee, and then in a written determination may return a worker to his/her former job status despite what would otherwise be unacceptably high biological monitoring results. Thereafter, the returned employee shall continue to be provided with medical surveillance as if he/she were still on medical removal until the employee's levels of CdU fall to or below 3 µg/g Cr, CdB falls to or below 5 µg/lwb, and ß2-M falls to or below 300 µg/g Cr.

(f) Where an employer, although not required by (a) through (c) of this subsection to do so, removes an employee from exposure to cadmium or otherwise places limitations on an employee due to the effects of cadmium exposure on the employee's medical condition, the employer shall provide the same medical removal protection benefits to that employee under subsection (12) of this section as would have been provided had the removal been required under (a) through (c) of this subsection.

(12) **Medical removal protection benefits (MRPB).**

(a) The employer shall provide MRPB for up to a maximum of eighteen months to an employee each time and while the employee is temporarily medically removed under subsection (11) of this section.

WAC 296-62-07423 (Cont.)

(b) For purposes of this section, the requirement that the employer provide MRPB means that the employer shall maintain the total normal earnings, seniority, and all other employee rights and benefits of the removed employee, including the employee's right to his/her former job status, as if the employee had not been removed from the employee's job or otherwise medically limited.

(c) Where, after eighteen months on medical removal because of elevated biological monitoring results, the employee's monitoring results have not declined to a low enough level to permit the employee to be returned to his/her former job status:

(i) The employer shall make available to the employee a medical examination pursuant in order to obtain a final medical determination as to whether the employee may be returned to his/her former job status or must be permanently removed from excess cadmium exposure; and

(ii) The employer shall assure that the final medical determination indicates whether the employee may be returned to his/her former job status and what steps, if any, should be taken to protect the employee's health.

(d) The employer may condition the provision of MRPB upon the employee's participation in medical surveillance provided in accordance with this section.

(13) **Multiple physician review.**

(a) If the employer selects the initial physician to conduct any medical examination or consultation provided to an employee under this section, the employee may designate a second physician to:

(i) Review any findings, determinations, or recommendations of the initial physician; and

(ii) Conduct such examinations, consultations, and laboratory tests as the second physician deems necessary to facilitate this review.

(b) The employer shall promptly notify an employee of the right to seek a second medical opinion after each occasion that an initial physician provided by the employer conducts a medical examination or consultation pursuant to this section. The employer may condition its participation in, and payment for, multiple physician review upon the employee doing the following within fifteen days after receipt of this notice, or receipt of the initial physician's written opinion, whichever is later:

(i) Informing the employer that he or she intends to seek a medical opinion; and

(ii) Initiating steps to make an appointment with a second physician.

(c) If the findings, determinations, or recommendations of the second physician differ from those of the initial physician, then the employer and the employee shall assure that efforts are made for the two physicians to resolve any disagreement.

(d) If the two physicians have been unable to quickly resolve their disagreement, then the employer and the employee, through their respective physicians, shall designate a third physician to:

(i) Review any findings, determinations, or recommendations of the other two physicians; and

WAC 296-62-07423 (Cont.)

(ii) Conduct such examinations, consultations, laboratory tests, and discussions with the other two physicians as the third physician deems necessary to resolve the disagreement among them.

(e) The employer shall act consistently with the findings, determinations, and recommendations of the third physician, unless the employer and the employee reach an agreement that is consistent with the recommendations of at least one of the other two physicians.

(14) **Alternate physician determination.** The employer and an employee or designated employee representative may agree upon the use of any alternate form of physician determination in lieu of the multiple physician review provided by subsection (13) of this section, so long as the alternative is expeditious and at least as protective of the employee.

(15) **Information the employer must provide the employee.**

(a) The employer shall provide a copy of the physician's written medical opinion to the examined employee within two weeks after receipt thereof.

(b) The employer shall provide the employee with a copy of the employee's biological monitoring results and an explanation sheet explaining the results within two weeks after receipt thereof.

(c) Within thirty days after a request by an employee, the employer shall provide the employee with the information the employer is required to provide the examining physician under subsection (9) of this section.

(16) **Reporting.** In addition to other medical events that are required to be reported on the OSHA Form No. 200, the employer shall report any abnormal condition or disorder caused by occupational exposure to cadmium associated with employment as specified in WAC 296-27-060.

[Statutory Authority: Chapter 49.17 RCW. 93-21-075 (Order 93-06), § 296-62-07423, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07423, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07425 Communication of cadmium hazards to employees.

(1) **General.** In communications concerning cadmium hazards, employers shall comply with the requirements of WISHA's chemical hazard communication standard, WAC 296-800-170, including but not limited to the requirements concerning warning signs and labels, material safety data sheets (MSDS), and employee information and training. In addition, employers shall comply with the following requirements:

(2) **Warning signs.**

(a) Warning signs shall be provided and displayed in regulated areas. In addition, warning signs shall be posted at all approaches to regulated areas so that an employee may read the signs and take necessary protective steps before entering the area.

(b) Warning signs required by (a) of this subsection shall bear the following information:

DANGER CADMIUM CANCER HAZARD CAN CAUSE LUNG AND KIDNEY DISEASE AUTHORIZED PERSONNEL ONLY RESPIRATORS REQUIRED IN THIS AREA

(c) The employer shall assure that signs required by this subsection are illuminated, cleaned, and maintained as necessary so that the legend is readily visible.

WAC 296-62-07425 (Cont.)

(3) **Warning labels.**

(a) Shipping and storage containers containing cadmium, cadmium compounds, or cadmium contaminated clothing, equipment, waste, scrap, or debris shall bear appropriate warning labels, as specified in (b) of this subsection.

(b) The warning labels shall include at least the following information:

DANGER CONTAINS CADMIUM CANCER HAZARD AVOID CREATING DUST CAN CAUSE LUNG AND KIDNEY DISEASE

(c) Where feasible, installed cadmium products shall have a visible label or other indication that cadmium is present.

(4) **Employee information and training.**

(a) The employer shall institute a training program for all employees who are potentially exposed to cadmium, assure employee participation in the program, and maintain a record of the contents of such program.

(b) Training shall be provided prior to or at the time of initial assignment to a job involving potential exposure to cadmium and at least annually thereafter.

(c) The employer shall make the training program understandable to the employee and shall assure that each employee is informed of the following:

(i) The health hazards associated with cadmium exposure, with special attention to the information incorporated in WAC 296-62-07441, Appendix A;

(ii) The quantity, location, manner of use, release, and storage of cadmium in the workplace and the specific nature of operations that could result in exposure to cadmium, especially exposures above the PEL;

(iii) The engineering controls and work-practices associated with the employee's job assignment;

(iv) The measures employees can take to protect themselves from exposure to cadmium, including modification of such habits as smoking and personal hygiene, and specific procedures the employer has implemented to protect employees from exposure to cadmium such as appropriate work-practices, emergency procedures, and the provision of personal protective equipment;

(v) The purpose, proper selection, fitting, proper use, and limitations of protective clothing;

(vi) The purpose and a description of the medical surveillance program required by WAC 296-62-07423;

(vii) The contents of this section and its appendices;

(viii) The employee's rights of access to records under WAC 296-62-05213 and 296-800-170; and

WAC 296-62-07425 (Cont.)

(ix) The purpose, proper use, limitations, and other training requirements for respiratory protection as required in chapter 296-62 WAC, part E.

(d) Additional access to information and training program and materials.

(i) The employer shall make a copy of this section and its appendices readily available without cost to all affected employees and shall provide a copy if requested.

(ii) The employer shall provide to the director, upon request, all materials relating to the employee information and the training program.

[Statutory Authority: RCW 49.17.010, .040, .050. 01-11-038 (Order 99-36), § 296-62-07425, filed 05/09/01, effective 09/01/01. Statutory Authority: RCW 49.17.010, .040, .050. 99-10 (Order 98-10) § 296-62-07425, filed 05/04/99, effective 09/01/99.] Statutory Authority: Chapter 49.17 RCW. 93-21-075 (Order 93-06), § 296-62-07425, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07425, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07427 Recordkeeping.

(1) **Exposure monitoring.**

(a) The employer shall establish and keep an accurate record of all air monitoring for cadmium in the workplace.

(b) This record shall include at least the following information:

(i) The monitoring date, duration, and results in terms of an 8-hour TWA of each sample taken;

(ii) The name, Social Security number, and job classification of the employees monitored and of all other employees whose exposures the monitoring is intended to represent;

(iii) A description of the sampling and analytical methods used and evidence of their accuracy;

(iv) The type of respiratory protective device, if any, worn by the monitored employee;

(v) A notation of any other conditions that might have affected the monitoring results.

(c) The employer shall maintain this record for at least thirty years, in accordance with chapter 296-802 WAC.

(2) **Objective data for exemption from requirement for initial monitoring.**

(a) For purposes of this section, objective data are information demonstrating that a particular product or material containing cadmium or a specific process, operation, or activity involving cadmium cannot release dust or fumes in concentrations at or above the action level even under the worst-case release conditions. Objective data can be obtained from an industry-wide study or from laboratory product test results from manufacturers of cadmium-containing products or materials. The data the employer uses from an industry-wide survey must be obtained under workplace conditions closely resembling the processes, types of material, control methods, work-practices and environmental conditions in the employer's current operations.

(b) The employer shall establish and maintain a record of the objective data for at least thirty years.

WAC 296-62-07427 (Cont.)

(3) **Medical surveillance.**

(a) The employer shall establish and maintain an accurate record for each employee covered by medical surveillance under WAC 296-62-07423 (1)(a).

(b) The record shall include at least the following information about the employee:

(i) Name, Social Security number, and description of the duties;

(ii) A copy of the physician's written opinions and an explanation sheet for biological monitoring results;

(iii) A copy of the medical history, and the results of any physical examination and all test results that are required to be provided by this section, including biological tests, x-rays, pulmonary function tests, etc., or that have been obtained to further evaluate any condition that might be related to cadmium exposure;

(iv) The employee's medical symptoms that might be related to exposure to cadmium; and

(v) A copy of the information provided to the physician as required by WAC 296-62-07423 (9)(b) through (e).

(c) The employer shall assure that this record is maintained for the duration of employment plus thirty years, in accordance with chapter 296-802 WAC.

(4) **Training.** The employer shall certify that employees have been trained by preparing a certification record which includes the identity of the person trained, the signature of the employer or the person who conducted the training, and the date the training was completed. The certification records shall be prepared at the completion of training and shall be maintained on file for one year beyond the date of training of that employee.

(5) **Availability.**

(a) Except as otherwise provided for in this section, access to all records required to be maintained by subsections (1) through (4) of this section shall be in accordance with the provisions of chapter 296-802 WAC.

(b) Within fifteen days after a request, the employer shall make an employee's medical records required to be kept by subsection (3) of this section available for examination and copying to the subject employee, to designated representatives, to anyone having the specific written consent of the subject employee, and after the employee's death or incapacitation, to the employee's family members.

(6) **Transfer of records.** Whenever an employer ceases to do business and there is no successor employer to receive and retain records for the prescribed period or the employer intends to dispose of any records required to be preserved for at least thirty years, the employer shall comply with the requirements concerning transfer of records set forth in chapter 296-802 WAC.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 04-10-026 (Order 03-04) § 296-62-07427, filed 04/27/04, effective 08/01/04. Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07427, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07429 Observation of monitoring.

(1) **Employee observation.** The employer shall provide affected employees or their designated representatives an opportunity to observe any monitoring of employee exposure to cadmium.

WAC 296-62-07429 (Cont.)

(2) **Observation procedures.** When observation of monitoring requires entry into an area where the use of protective clothing or equipment is required, the employer shall provide the observer with that clothing and equipment and shall assure that the observer uses such clothing and equipment and complies with all other applicable safety and health procedures.

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07429, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07433 Appendices. WAC 296-62-07441, appendix A; WAC 296-62-07443, appendix B; WAC 296-62-07447, appendix D; WAC 296-62-07449, appendix E; and WAC 296-62-07451, appendix F are nonmandatory appendices and are not intended to create any additional obligations.

[Statutory Authority: RCW 49.17.010, .040, .050. 99-17-094 (Order 99-01), § 296-62-07433, filed 08/17/99, effective 12/01/99. Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07433, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07441 Appendix A--substance safety data sheet--Cadmium.

(1) **Substance identification.**

(a) Substance: Cadmium.

(b) 8-Hour, time-weighted-average, permissible exposure limit (TWA PEL):

(c) TWA PEL: Five micrograms of cadmium per cubic meter of air 5 $\mu g/m^3$, time-weighted average (TWA) for an 8-hour workday.

(d) Appearance: Cadmium metal--soft, blue-white, malleable, lustrous metal or grayish-white powder. Some cadmium compounds may also appear as a brown, yellow, or red powdery substance.

(2) **Health hazard data.**

(a) Routes of exposure. Cadmium can cause local skin or eye irritation. Cadmium can affect your health if you inhale it or if you swallow it.

(b) Effects of overexposure.

(i) Short-term (acute) exposure: Cadmium is much more dangerous by inhalation than by ingestion. High exposures to cadmium that may be immediately dangerous to life or health occur in jobs where workers handle large quantities of cadmium dust or fume; heat cadmium-containing compounds or cadmium-coated surfaces; weld with cadmium solders or cut cadmium-containing materials such as bolts.

(ii) Severe exposure may occur before symptoms appear. Early symptoms may include mild irritation of the upper respiratory tract, a sensation of constriction of the throat, a metallic taste and/or a cough. A period of one to ten hours may precede the onset of rapidly progressing shortness of breath, chest pain, and flu-like symptoms with weakness, fever, headache, chills, sweating, and muscular pain. Acute pulmonary edema usually develops within twenty-four hours and reaches a maximum by three days. If death from asphyxia does not occur, symptoms may resolve within a week.

(iii) Long-term (chronic) exposure. Repeated or long-term exposure to cadmium, even at relatively low concentrations, may result in kidney damage and an increased risk of cancer of the lung and of the prostate.

(c) Emergency first aid procedures.

WAC 296-62-07441 (Cont.)

(i) Eye exposure: Direct contact may cause redness or pain. Wash eyes immediately with large amounts of water, lifting the upper and lower eyelids. Get medical attention immediately.

(ii) Skin exposure: Direct contact may result in irritation. Remove contaminated clothing and shoes immediately. Wash affected area with soap or mild detergent and large amounts of water. Get medical attention immediately.

(iii) Ingestion: Ingestion may result in vomiting, abdominal pain, nausea, diarrhea, headache, and sore throat. Treatment for symptoms must be administered by medical personnel. Under no circumstances should the employer allow any person whom he/she retains, employs, supervises, or controls to engage in therapeutic chelation. Such treatment is likely to translocate cadmium from pulmonary or other tissue to renal tissue. Get medical attention immediately.

(iv) Inhalation: If large amounts of cadmium are inhaled, the exposed person must be moved to fresh air at once. If breathing has stopped, perform cardiopulmonary resuscitation. Administer oxygen if available. Keep the affected person warm and at rest. Get medical attention immediately.

(v) Rescue: Move the affected person from the hazardous exposure. If the exposed person has been overcome, attempt rescue only after notifying at least one other person of the emergency and putting into effect established emergency procedures. Do not become a casualty yourself. Understand your emergency rescue procedures and know the location of the emergency equipment before the need arises.

(3) **Employee information.**

(a) Protective clothing and equipment.

(i) Respirators: You may be required to wear a respirator for nonroutine activities; in emergencies; while your employer is in the process of reducing cadmium exposures through engineering controls; and where engineering controls are not feasible. If air-purifying respirators are worn , they must have a label issued by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 42 CFR part 84 stating that the respirators have been certified for use with cadmium. Cadmium does not have a detectable odor except at levels well above the permissible exposure limits. If you can smell cadmium while wearing a respirator, proceed immediately to fresh air. If you experience difficulty breathing while wearing a respirator, tell your employer.

(ii) Protective clothing: You may be required to wear impermeable clothing, gloves, foot gear, a face shield, or other appropriate protective clothing to prevent skin contact with cadmium. Where protective clothing is required, your employer must provide clean garments to you as necessary to assure that the clothing protects you adequately. The employer must replace or repair protective clothing that has become torn or otherwise damaged.

(iii) Eye protection: You may be required to wear splash-proof or dust resistant goggles to prevent eye contact with cadmium.

(b) Employer requirements.

WAC 296-62-07441 (Cont.)

(i) Medical: If you are exposed to cadmium at or above the action level, your employer is required to provide a medical examination, laboratory tests and a medical history according to the medical surveillance provisions under WAC 296-62-07423. (See summary chart and tables in this section, appendix A.) These tests shall be provided without cost to you. In addition, if you are accidentally exposed to cadmium under conditions known or suspected to constitute toxic exposure to cadmium, your employer is required to make special tests available to you.

(ii) Access to records: All medical records are kept strictly confidential. You or your representative are entitled to see the records of measurements of your exposure to cadmium. Your medical examination records can be furnished to your personal physician or designated representative upon request by you to your employer.

(iii) Observation of monitoring: Your employer is required to perform measurements that are representative of your exposure to cadmium and you or your designated representative are entitled to observe the monitoring procedure. You are entitled to observe the steps taken in the measurement procedure, and to record the results obtained. When the monitoring procedure is taking place in an area where respirators or personal protective clothing and equipment are required to be worn, you or your representative must also be provided with, and must wear the protective clothing and equipment.

(c) Employee requirements. You will not be able to smoke, eat, drink, chew gum or tobacco, or apply cosmetics while working with cadmium in regulated areas. You will also not be able to carry or store tobacco products, gum, food, drinks, or cosmetics in regulated areas because these products easily become contaminated with cadmium from the workplace and can therefore create another source of unnecessary cadmium exposure. Some workers will have to change out of work clothes and shower at the end of the day, as part of their workday, in order to wash cadmium from skin and hair. Handwashing and cadmium-free eating facilities shall be provided by the employer and proper hygiene should always be performed before eating. It is also recommended that you do not smoke or use tobacco products, because among other things, they naturally contain cadmium. For further information, read the labeling on such products.

(4) **Physician information.**

(a) Introduction. The medical surveillance provisions of WAC 296-62-07423 generally are aimed at accomplishing three main interrelated purposes: First, identifying employees at higher risk of adverse health effects from excess, chronic exposure to cadmium; second, preventing cadmium-induced disease; and third, detecting and minimizing existing cadmium-induced disease. The core of medical surveillance in this standard is the early and periodic monitoring of the employee's biological indicators of:

(i) Recent exposure to cadmium;

(ii) Cadmium body burden; and

(iii) Potential and actual kidney damage associated with exposure to cadmium. The main adverse health effects associated with cadmium overexposure are lung cancer and kidney dysfunction. It is not yet known how to adequately biologically monitor human beings to specifically prevent cadmium-induced lung cancer. By contrast, the kidney can be monitored to provide prevention and early detection of cadmium-induced kidney damage. Since, for noncarcinogenic effects, the kidney is considered the primary target organ of chronic exposure to cadmium, the medical surveillance provisions of this standard effectively focus on cadmium-induced kidney disease. Within that focus, the

aim, where possible, is to prevent the onset of such disease and, where necessary, to minimize such disease as may already exist. The by-products of successful prevention of kidney disease are anticipated to be the reduction and prevention of other cadmium-induced diseases.

(b) Health effects. The major health effects associated with cadmium overexposure are described below.

(i) Kidney: The most prevalent nonmalignant disease observed among workers chronically exposed to cadmium is kidney dysfunction. Initially, such dysfunction is manifested as proteinuria. The proteinuria associated with cadmium exposure is most commonly characterized by excretion of low-molecular weight proteins (15,000 to 40,000 MW) accompanied by loss of electrolytes, uric acid, calcium, amino acids, and phosphate. The compounds commonly excreted include: beta-2-microglobulin (ß2-M), retinol binding protein (RBP), immunoglobulin light chains, and lysozyme. Excretion of low molecular weight proteins are characteristic of damage to the proximal tubules of the kidney (Iwao et al., 1980). It has also been observed that exposure to cadmium may lead to urinary excretion of high-molecular weight proteins such as albumin, immunoglobulin G, and glycoproteins (Ex. 29). Excretion of high-molecular weight proteins is typically indicative of damage to the glomeruli of the kidney. Bernard et al., (1979) suggest that damage to the glomeruli and damage to the proximal tubules of the kidney may both be linked to cadmium exposure but they may occur independently of each other. Several studies indicate that the onset of low-molecular weight proteinuria is a sign of irreversible kidney damage (Friberg et al., 1974; Roels et al., 1982; Piscator 1984; Elinder et al., 1985; Smith et al., 1986). Above specific levels of ß2-M associated with cadmium exposure it is unlikely that ß2-M levels return to normal even when cadmium exposure is eliminated by removal of the individual from the cadmium work environment (Friberg, Ex. 29, 1990). Some studies indicate that such proteinuria may be progressive; levels of ß2-M observed in the urine increase with time even after cadmium exposure has ceased. See, for example, Elinder et al., 1985. Such observations, however, are not universal, and it has been suggested that studies in which proteinuria has not been observed to progress may not have tracked patients for a sufficiently long time interval (Jarup, Ex. 8-661). When cadmium exposure continues after the onset of proteinuria, chronic nephrotoxicity may occur (Friberg, Ex. 29). Uremia results from the inability of the glomerulus to adequately filter blood. This leads to severe disturbance of electrolyte concentrations and may lead to various clinical complications including kidney stones (L-140-50). After prolonged exposure to cadmium, glomerular proteinuria, glucosuria, aminoaciduria, phosphaturia, and hypercalciuria may develop (Exs. 8-86, 4-28, 14-18). Phosphate, calcium, glucose, and amino acids are essential to life, and under normal conditions, their excretion should be regulated by the kidney. Once low molecular weight proteinuria has developed, these elements dissipate from the human body. Loss of glomerular function may also occur, manifested by decreased glomerular filtration rate and increased serum creatinine. Severe cadmium-induced renal damage may eventually develop into chronic renal failure and uremia (Ex. 55). Studies in which animals are chronically exposed to cadmium confirm the renal effects observed in humans (Friberg et al., 1986). Animal studies also confirm problems with calcium metabolism and related skeletal effects which have been observed among humans exposed to cadmium in addition to the renal effects. Other effects commonly reported in chronic animal studies include anemia, changes in liver morphology, immunosuppression and hypertension. Some of these effects may be associated with co-factors. Hypertension, for example, appears to be associated with diet as well as cadmium exposure. Animals injected with cadmium have also shown testicular necrosis (Ex. 8- 86B).

WAC 296-62-07441 (Cont.)

(ii) Biological markers. It is universally recognized that the best measures of cadmium exposures and its effects are measurements of cadmium in biological fluids, especially urine and blood. Of the two, CdU is conventionally used to determine body burden of cadmium in workers without kidney disease. CdB is conventionally used to monitor for recent exposure to cadmium. In addition, levels of CdU and CdB historically have been used to predict the percent of the population likely to develop kidney disease (Thun et al., Ex. L-140-50; WHO, Ex. 8-674; ACGIH, Exs. 8-667, 140-50). The third biological parameter upon which WISHA relies for medical surveillance is beta-2-microglobulin in urine (ß2-M), alow molecular weight protein. Excess ß2-M has been widely accepted by physicians and scientists as a reliable indicator of functional damage to the proximal tubule of the kidney

(Exs. 8-447, 144-3-C, 4-47, L-140-45, 19-43-A). Excess ß2-M is found when the proximal tubules can no longer reabsorb this protein in a normal manner. This failure of the proximal tubules is an early stage of a kind of kidney disease that commonly occurs among workers with excessive cadmium exposure. Used in conjunction with biological test results indicating abnormal levels of CdU and CdB, the finding of excess ß2-M can establish for an examining physician that any existing kidney disease is probably cadmium-related (Trs. 6/6/90, pp. 82-86, 122, 134). The upper limits of normal levels for cadmium in urine and cadmium in blood are 3 µg Cd/gram creatinine in urine and 5 µg Cd/liter whole blood, respectively. These levels were derived from broad-based population studies. Three issues confront the physicians in the use of ß2-M as a marker of kidney dysfunction and material impairment. First, there are a few other causes of elevated levels of ß2-M not related to cadmium exposures, some of which may be rather common diseases and some of which are serious diseases (e.g., myeloma or transient flu, Exs. 29 and 8-086). These can be medically evaluated as alternative causes (Friberg, Ex. 29). Also, there are other factors that can cause ß2-M to degrade so that low levels would result in workers with tubular dysfunction. For example, regarding the degradation of ß2-M, workers with acidic urine (pH<6) might have ß2-M levels that are within the “normal” range when in fact kidney dysfunction has occurred (Ex. L-140-1) and the low molecular weight proteins are degraded in acid urine.

Thus, it is very important that the pH of urine be measured, that urine samples be buffered as necessary (See WAC 296-62-07451, appendix F.), and that urine samples be handled correctly, i.e., measure the pH of freshly voided urine samples, then if necessary, buffer to Ph>6 (or above for shipping purposes), measure Ph again and then, perhaps, freeze the sample for storage and shipping. (See also WAC 296-62-07451, appendix F.) Second, there is debate over the pathological significance of proteinuria, however, most world experts believe that ß2-M levels greater than 300 µg/g Cr are abnormal (Elinder, Ex. 55, Friberg, Ex. 29). Such levels signify kidney dysfunction that constitutes material impairment of health. Finally, detection of ß2-M at low levels has often been considered difficult, however, many laboratories have the capability of detecting excess ß2-M using simple kits, such as the Phadebas Delphia test, that are accurate to levels of 100 µg ß2-M/g Cr U (Ex. L-140-1). Specific recommendations for ways to measure ß2-M and proper handling of urine samples to prevent degradation of ß2-M have been addressed by WISHA in WAC 296-62-07451, appendix F, in the section on laboratory standardization. All biological samples must be analyzed in a laboratory that is proficient in the analysis of that particular analyte, under WAC 296-62-07423 (1)(d). (See WAC 296-62-07451, appendix F). Specifically, under WAC 296-62-07423 (1)(d), the employer is to assure that the collecting and handling of biological samples of cadmium in urine (CdU), cadmium in blood (CdB), and beta-2 microglobulin in urine (ß2-M) taken from employees is collected in a manner that assures reliability. The employer must also assure that analysis of biological samples of cadmium in urine (CdU), cadmium in blood

WAC 296-62-07441 (Cont.)

(CdB), and beta-2 microglobulin in urine (ß2-M) taken from employees is performed in laboratories with demonstrated proficiency for that particular analyte. (See WAC 296-62-07451, appendix F).

(iii) Lung and prostate cancer. The primary sites for cadmium-associated cancer appear to be the lung and the prostate (L-140-50). Evidence for an association between cancer and cadmium exposure derives from both epidemiological studies and animal experiments. Mortality from prostate cancer associated with cadmium is slightly elevated in several industrial cohorts, but the number of cases is small and there is not clear dose-response relationship. More substantive evidence exists for lung cancer. The major epidemiological study of lung cancer was conducted by Thun et al., (Ex. 4-68). Adequate data on cadmium exposures were available to allow evaluation of dose-response relationships between cadmium exposure and lung cancer. A statistically significant excess of lung cancer attributed to cadmium exposure was observed in this study even when confounding variables such as co-exposure to arsenic and smoking habits were taken into consideration (Ex. L-140-50). The primary evidence for quantifying a link between lung cancer and cadmium exposure from animal studies derives from two rat bioassay studies; one by Takenaka et al., (1983), which is a study of cadmium chloride and a second study by Oldiges and Glaser (1990) of four cadmium compounds. Based on the above cited studies, the U.S. Environmental Protection Agency (EPA) classified cadmium as "B1", a probable human carcinogen, in 1985 (Ex. 4-4). The International Agency for Research on Cancer (IARC) in 1987 also recommended that cadmium be listed as "2A", a probable human carcinogen (Ex. 4-15). The American Conference of Governmental Industrial Hygienists (ACGIH) has recently recommended that cadmium be labeled as a carcinogen. Since 1984, NIOSH has concluded that cadmium is possibly a human carcinogen and has recommended that exposures be controlled to the lowest level feasible.

(iv) Noncarcinogenic effects. Acute pneumonitis occurs 10 to 24 hours after initial acute inhalation of high levels of cadmium fumes with symptoms such as fever and chest pain (Exs. 30, 8-86B). In extreme exposure cases pulmonary edema may develop and cause death several days after exposure. Little actual exposure measurement data is available on the level of airborne cadmium exposure that causes such immediate adverse lung effects, nonetheless, it is reasonable to believe cadmium concentration of approximately 1 mg/m3 over an eight hour period is "immediately dangerous" (55 FR 4052, ANSI; Ex. 8-86B). In addition to acute lung effects and chronic renal effects, long term exposure to cadmium may cause other severe effects on the respiratory system. Reduced pulmonary function and chronic lung disease indicative of emphysema have been observed in workers who have had prolonged exposure to cadmium dust or fumes (Exs. 4-29, 4-22, 4-42, 4-50, 4-63). In a study of workers conducted by Kazantzis et al., a statistically significant excess of worker deaths due to chronic bronchitis was found, which in his opinion was directly related to high cadmium exposures of 1 mg/m3 or more (Tr. 6/8/90, pp. 156-157). Cadmium need not be respirable to constitute a hazard. Inspirable cadmium particles that are too large to be respirable but small enough to enter the tracheobronchial region of the lung can lead to bronchoconstriction, chronic pulmonary disease, and cancer of that portion of the lung. All of these diseases have been associated with occupational exposure to cadmium (Ex. 8- 86B). Particles that are constrained by their size to the extra-thoracic regions of the respiratory system such as the nose and maxillary sinuses can be swallowed through mucocillary clearance and be absorbed into the body (ACGIH, Ex. 8-692). The impaction of these particles in the upper airways can lead to anosmia, or loss of sense of smell, which is an early indication of overexposure among workers exposed to heavy metals. This condition is commonly reported among cadmium-exposed workers (Ex. 8-86-B).

WAC 296-62-07441 (Cont.)

(c) Medical surveillance. In general, the main provisions of the medical surveillance section of the standard, under WAC 296-62-07423 (1) through (16), are as follows:

(i) Workers exposed above the action level are covered;

(ii) Workers with intermittent exposures are not covered;

(iii) Past workers who are covered receive biological monitoring for at least one year;

(iv) Initial examinations include a medical questionnaire and biological monitoring of cadmium in blood (CdB), cadmium in urine (CdU), and Beta-2-microglobulin in urine (ß2-M);

(v) Biological monitoring of these three analytes is performed at least annually; full medical examinations are performed biennially;

(vi) Until five years from the effective date of the standard, medical removal is required when CdU is greater than 15 µg/gram creatinine (g Cr), or CdB is greater than 15 µg/liter whole blood (lwb), or ß2-M is greater than 1500 µg/g Cr, and CdB is greater than 5 µg/lwb or CdU is greater than 3 µg/g Cr;

(vii) Beginning five years after the standard is in effect, medical removal triggers will be reduced;

(viii) Medical removal protection benefits are to be provided for up to eighteen months;

(ix) Limited initial medical examinations are required for respirator usage;

(x) Major provisions are fully described under WAC 296-62-07423; they are outlined here as follows:

(A) Eligibility.

(B) Biological monitoring.

(C) Actions triggered by levels of CdU, CdB, and ß2-M (See Summary Charts and Tables in WAC 296-62-07441(5).)

(D) Periodic medical surveillance.

(E) Actions triggered by periodic medical surveillance (See appendix A Summary Chart and Tables in WAC 296-62-07441(5).)

(F) Respirator usage.

(G) Emergency medical examinations.

(H) Termination examination.

(I) Information to physician.

(J) Physician's medical opinion.

(K) Medical removal protection.

WAC 296-62-07441 (Cont.)

(L) Medical removal protection benefits.

(M) Multiple physician review.

(N) Alternate physician review.

(O) Information employer gives to employee.

(P) Recordkeeping.

(Q) Reporting on OSHA form 200.

(xi) The above mentioned summary of the medical surveillance provisions, the summary chart, and tables for the actions triggered at different levels of CdU, CdB and ß2-M (in subsection (5) of this section, Attachment 1) are included only for the purpose of facilitating understanding of the provisions of WAC 296-62-07423(3) of the final cadmium standard. The summary of the provisions, the summary chart, and the tables do not add to or reduce the requirements in WAC 296-62-07423(3).

(d) Recommendations to physicians.

(i) It is strongly recommended that patients with tubular proteinuria are counseled on: The hazards of smoking; avoidance of nephrotoxins and certain prescriptions and over-the-counter medications that may exacerbate kidney symptoms; how to control diabetes and/or blood pressure; proper hydration, diet, and exercise (Ex. 19-2). A list of prominent or common nephrotoxins is attached. (See subsection (6) of this section, Attachment 2.)

(ii) DO NOT CHELATE; KNOW WHICH DRUGS ARE NEPHROTOXINS OR ARE ASSOCIATED WITH NEPHRITIS.

(iii) The gravity of cadmium-induced renal damage is compounded by the fact there is no medical treatment to prevent or reduce the accumulation of cadmium in the kidney (Ex. 8-619). Dr. Friberg, a leading world expert on cadmium toxicity, indicated in 1992, that there is no form of chelating agent that could be used without substantial risk. He stated that tubular proteinuria has to be treated in the same way as other kidney disorders (Ex. 29).

(iv) After the results of a workers' biological monitoring or medical examination are received the employer is required to provide an information sheet to the patient, briefly explaining the significance of the results. (See subsection (7) of this section.)

(v) For additional information the physician is referred to the following additional resources:

(A) The physician can always obtain a copy of the OSHA final rule preamble, with its full discussion of the health effects, from OSHA's Computerized Information System (OCIS).

(B) The OSHA Docket Officer maintains a record of the OSHA rulemaking. The Cadmium Docket (H-057A), is located at 200 Constitution Ave. NW., Room N-2625, Washington, DC 20210; telephone: (202) 219-7894.

(C) The following articles and exhibits in particular from that docket (H- 057A):

WAC 296-62-07441 (Cont.)

Exhibit number	Author and paper title
8-447	Lauwerys et. al., Guide for physicians, "Health Maintenance of Workers Exposed to Cadmium," published by the Cadmium Council.
4-67	Takenaka, S., H. Oldiges, H. Konig, D. Hochrainer, G. Oberdorster. "Carcinogenicity of Cadmium Chloride Aerosols in Wistar Rats". JNCI 70:367-373, 1983. (32)
4-68	Thun, M.J., T.M. Schnoor, A.B. Smith, W.E. Halperin, R.A. Lemen. "Mortality Among a Cohort of U.S. Cadmium Production Workers--An Update." JNCI 74(2):325-33, 1985. (8)
4-25	Elinder, C.G., Kjellstrom, T., Hogstedt, C., et al., "Cancer Mortality of Cadmium Workers." Brit. J. Ind. Med. 42:651-655, 1985. (14)
4-26	Ellis, K.J. et al., "Critical Concentrations of Cadmium in Human Renal Cortex: Dose Effect Studies to Cadmium Smelter Workers." J. Toxicol. Environ. Health 7:691-703, 1981. (76)
4-27	Ellis, K.J., S.H. Cohn and T.J. Smith. "Cadmium Inhalation Exposure Estimates: Their Significance with Respect to Kidney and Liver Cadmium Burden." J. Toxicol. Environ. Health 15:173-187, 1985.
4-28	Falck, F.Y., Jr., Fine, L.J., Smith, R.G., McClatchey, K.D., Annesley, T., England, B., and Schork, A.M. "Occupational Cadmium Exposure and Renal Status." Am. J. Ind. Med. 4:541, 1983. (64)
8-86A	Friberg, L., C.G. Elinder, et al., "Cadmium and Health a Toxicological and Epidemiological Appraisal, Volume I, Exposure, Dose, and Metabolism." CRC Press, Inc., Boca Raton, FL, 1986. (Available from the OSHA Technical Data Center)
8-86B	Friberg, L., C.G. Elinder, et al., "Cadmium and Health: A Toxicological and Epidemiological Appraisal, Volume II, Effects and Response." CRC Press, Inc., Boca Raton, FL, 1986. (Available from the OSHA Technical Data Center)
L-140-45	Elinder, C.G., "Cancer Mortality of Cadmium Workers", Brit. J. Ind. Med., 42, 651-655, 1985.
L-140-50	Thun, M., Elinder, C.G., Friberg, L, "Scientific Basis for an Occupational Standard for Cadmium, Am. J. Ind. Med., 20; 629-642, 1991.

(5) **Information sheet.** The information sheet (subsection (8) of this section, Attachment 3) or an equally explanatory one should be provided to you after any biological monitoring results are reviewed by the physician, or where applicable, after any medical examination.

(6) **Attachment 1--Appendix A,** summary chart and Tables A and B of actions triggered by biological monitoring.

(a) Summary chart: WAC 296-62-07423(3) Medical surveillance--Categorizing biological monitoring results.

WAC 296-62-07441 (Cont.)

(i) Biological monitoring results categories are set forth in Table A for the periods ending December 31, 1998, and for the period beginning January 1, 1999.

(ii) The results of the biological monitoring for the initial medical exam and the subsequent exams shall determine an employee's biological monitoring result category.

(b) Actions triggered by biological monitoring.

(i) The actions triggered by biological monitoring for an employee are set forth in Table B.

(ii) The biological monitoring results for each employee under WAC 296-62-07423(3) shall determine the actions required for that employee. That is, for any employee in biological monitoring category C, the employer will perform all of the actions for which there is an X in column C of Table B.

(iii) An employee is assigned the alphabetical category ("A" being the lowest) depending upon the test results of the three biological markers.

(iv) An employee is assigned category A if monitoring results for all three biological markers fall at or below the levels indicated in the table listed for category A.

(v) An employee is assigned category B if any monitoring result for any of the three biological markers fall within the range of levels indicated in the table listed for category B, providing no result exceeds the levels listed for category B.

(vi) An employee is assigned category C if any monitoring result for any of the three biological markers are above the levels listed for category C.

(c) The user of Tables A and B should know that these tables are provided only to facilitate understanding of the relevant provisions of WAC 296-62-07423. Tables A and B are not meant to add to or subtract from the requirements of those provisions.

Table A
Categorization of Biological Monitoring Results
Applicable Through 1998 Only

	Monitoring result categories		
Biological marker	**A**	**B**	**C**
Cadmium in urine (CdU) (µg/g creatinine)	≤ = 3	>3 and ≤ = 15	>15
ß2-microglobulin (ß2-M) (µg/g creatinine)	≤ = 300	>300 and ≤ = 1500	>1500*
Cadmium in blood (CdB) (µg/liter whole blood)	≤ = 5	>5 and ≤ = 15	>15

* If an employee's ß2-M levels are above 1,500 µg/g creatinine, in order for mandatory medical removal to be required (See WAC 296-62-07441, Appendix A Table B.), either the employee's CdU level must also be >3 µg/g creatinine or CdB level must also be >5 µg/liter whole blood.

WAC 296-62-07441 (Cont.)

Applicable Beginning January 1, 1999 Monitoring result categories			
Biological marker	A	B	C
Cadmium in urine (CdU) (µg/g creatinine)	≤ = 3	>3 and ≤ = 7	>7
ß2-microglobulin (ß2-M) (µg/g creatinine)	≤ = 300	>300 and ≤ = 750	>750*
Cadmium in blood (CdB) (µg/liter whole blood)	≤ = 5	>5 and ≤ = 10	>10

* If an employee's ß2-M levels are above 750 µg/g creatinine, in order for mandatory medical removal to be required (See WAC 296-62-07441, Appendix A Table B.), either the employee's CdU level must also be >3 µg/g creatinine or CdB level must also be >5 µg/liter whole blood.

Table B--Actions determined by biological monitoring.

This table presents the actions required based on the monitoring result in Table A. Each item is a separate requirement in citing noncompliance. For example, a medical examination within ninety days for an employee in category B is separate from the requirement to administer a periodic medical examination for category B employees on an annual basis.

Table B Monitoring result category			
Required actions	A[1]	B[1]	C[1]
(1) Biological monitoring:			
(a) Annual.	X		
(b) Semiannual.		X	
(c) Quarterly.			X
(2) Medical examination:			
(a) Biennial.	X		
(b) Annual.		X	
(c) Semiannual.			X
(d) Within 90 days.		X	X
(3) Assess within two weeks:			
(a) Excess cadmium exposure.		X	X
(b) Work-practices.		X	X
(c) Personal hygiene.		X	X
(d) Respirator usage.		X	X
(e) Smoking history.		X	X
(f) Hygiene facilities.		X	X
(g) Engineering controls.		X	X
(h) Correct within 30 days.		X	X
(i) Periodically assess exposures.			X
(4) Discretionary medical removal.		X	X
(5) Mandatory medical removal.			X[2]

[1] For all employees covered by medical surveillance exclusively because of exposures prior to the effective date of this standard, if they are in Category A, the employer shall follow the requirements of WAC 296-62-07423 (3)(a)(ii) and (4)(e)(i). If they are in Category B or C, the employer shall follow the requirements of WAC 296-62-07423 (4)(e)(ii) and (iii).

WAC 296-62-07441 (Cont.)

[2] See footnote in Table A.

(7) **Attachment 2, list of medications.**

(a) A list of the more common medications that a physician, and the employee, may wish to review is likely to include some of the following:

(i) Anticonvulsants: Paramethadione, phenytoin, trimethadone;

(ii) Antihypertensive drugs: Captopril, methyldopa;

(iii) Antimicrobials: Aminoglycosides, amphotericin B, cephalosporins, ethambutol;

(iv) Antineoplastic agents: Cisplatin, methotrexate, mitomycin-C, nitrosoureas, radiation;

(v) Sulfonamide diuretics: Acetazolamide, chlorthalidone, furosemide, thiazides;

(vi) Halogenated alkanes, hydrocarbons, and solvents that may occur in some settings: Carbon tetrachloride, ethylene glycol, toluene; iodinated radiographic contrast media; nonsteroidal anti-inflammatory drugs; and

(vii) Other miscellaneous compounds: Acetaminophen, allopurinol, amphetamines, azathioprine, cimetidine, cyclosporine, lithium, methoxyflurane, methysergide, D-penicillamine, phenacetin, phenendione.

(b) A list of drugs associated with acute interstitial nephritis includes:

(i) Antimicrobial drugs: Cephalosporins, chloramphenicol, colistin, erythromycin, ethambutol, isoniazid, para-aminosalicylic acid, penicillins, polymyxin B, rifampin, sulfonamides, tetracyclines, and vancomycin;

(ii) Other miscellaneous drugs: Allopurinol, antipyrine, azathioprine, captopril, cimetidine, clofibrate, methyldopa, phenindione, phenylpropanolamine, phenytoin, probenecid, sulfinpyrazone, sulfonamide diuretics, triamterene; and

(iii) Metals: Bismuth, gold. This list has been derived from commonly available medical textbooks (e.g., Ex. 14-18). The list has been included merely to facilitate the physician's, employer's, and employee's understanding. The list does not represent an official OSHA opinion or policy regarding the use of these medications for particular employees. The use of such medications should be under physician discretion.

(8) **Attachment 3--Biological monitoring and medical examination results.**

Employee_____

Testing Date_____

Cadmium in Urine ___ µg/g Cr--Normal Levels: ≤ = 3 µg/g Cr.

Cadmium in Blood ___ µg/lwb--Normal Levels: ≤ = 5 µg/lwb.

Beta-2-microglobulin in Urine ___ µg/g Cr—Normal Levels: ≤ = 300 µg/g Cr.

WAC 296-62-07441 (Cont.)

Physical Examination Results: N/A ___ Satisfactory ___ Unsatisfactory ___ (see physician again).

Physician's Review of Pulmonary Function Test: N/A ___ Normal ___ Abnormal ___.

Next biological monitoring or medical examination scheduled for _____.

(a) The biological monitoring program has been designed for three main purposes:

(i) To identify employees at risk of adverse health effects from excess, chronic exposure to cadmium;

(ii) To prevent cadmium-induced disease(s); and

(iii) To detect and minimize existing cadmium-induced disease(s).

(b) The levels of cadmium in the urine and blood provide an estimate of the total amount of cadmium in the body. The amount of a specific protein in the urine (beta-2-microglobulin) indicates changes in kidney function. All three tests must be evaluated together. A single mildly elevated result may not be important if testing at a later time indicates that the results are normal and the workplace has been evaluated to decrease possible sources of cadmium exposure. The levels of cadmium or beta-2-microglobulin may change over a period of days to months and the time needed for those changes to occur is different for each worker.

(c) If the results for biological monitoring are above specific “high levels” (cadmium urine greater than 10 micrograms per gram of creatinine µg/ Cr), cadmium blood greater than 10 micrograms per liter of whole blood (µg/lwb), or beta-2-microglobulin greater than 1000 micrograms per gram of creatinine (µg/g Cr), the worker has a much greater chance of developing other kidney diseases.

(d) One way to measure for kidney function is by measuring beta-2-microglobulin in the urine. Beta-2-microglobulin is a protein which is normally found in the blood as it is being filtered in the kidney, and the kidney reabsorbs or returns almost all of the beta-2-microglobulin to the blood. A very small amount (less than 300 µg/g Cr in the urine) of beta-2-microglobulin is not reabsorbed into the blood, but is released in the urine. If cadmium damages the kidney, the amount of beta-2-microglobulin in the urine increases because the kidney cells are unable to reabsorb the beta-2-microglobulin normally. An increase in the amount of beta-2-microglobulin in the urine is a very early sign of kidney dysfunction. A small increase in beta-2-microglobulin in the urine will serve as an early warning sign that the worker may be absorbing cadmium from the air, cigarettes contaminated in the workplace, or eating in areas that are cadmium contaminated.

(e) Even if cadmium causes permanent changes in the kidney's ability to reabsorb beta-2-microglobulin, and the beta-2-microglobulin is above the “high levels,” the loss of kidney function may not lead to any serious health problems. Also, renal function naturally declines as people age. The risk for changes in kidney function for workers who have biological monitoring results between the “normal values” and the “high levels” is not well known. Some people are more cadmium-tolerant, while others are more cadmium-susceptible.

(f) For anyone with even a slight increase of beta-2-microglobulin, cadmium in the urine, or cadmium in the blood, it is very important to protect the kidney from further damage. Kidney damage can come from other sources than excess cadmium-exposure so it is also recommended that if a worker's levels are “high” he/she should receive counseling about drinking more water; avoiding cadmium-tainted tobacco and certain medications (nephrotoxins, acetaminophen); controlling diet, vitamin intake, blood pressure and diabetes; etc.

[Statutory Authority: RCW 49.17.010, .040, .050. 99-10 (Order 98-10) § 296-62-07271, filed 05/04/99, effective 09/01/99.]
[Statutory Authority: Chapter 49.17 RCW. 94-15-096 (Order 94-07), § 296-62-07441, filed 7/20/94, effective 9/20/94; 93-21-075 (Order 93-06), § 296-62-07441, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07441, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07443 Appendix B--Substance technical guidelines for cadmium.

(1) **Cadmium metal.**

(a) Physical and chemical data.

(i) Substance identification.

Chemical name: Cadmium.

Formula: Cd.

Molecular Weight: 112.4.

Chemical Abstracts Service (CAS) Registry No.: 7740-43-9.

Other identifiers: RETCS EU9800000; EPA D006; DOT 2570 53.

Synonyms: Colloidal Cadmium: Kadmium (German): CI 77180.

(ii) Physical data.

Boiling point: (760 mm Hg): 765 degrees C.

Melting point: 321 degrees C.

Specific gravity: (H_2O = @ 20°C): 8.64.

Solubility: Insoluble in water; soluble in dilute nitric acid and in sulfuric acid.

Appearance: Soft, blue-white, malleable, lustrous metal or grayish-white powder.

(b) Fire, explosion, and reactivity data.

(i) Fire.

Fire and explosion hazards: The finely divided metal is pyrophoric, that is the dust is a severe fire hazard and moderate explosion hazard when exposed to heat or flame. Burning material reacts violently with extinguishing agents such as water, foam, carbon dioxide, and halons.

Flash point: Flammable (dust).

Extinguishing media: Dry sand, dry dolomite, dry graphite, or sodium chloride.

(ii) Reactivity.

Conditions contributing to instability: Stable when kept in sealed containers under normal temperatures and pressure, but dust may ignite upon contact with air. Metal tarnishes in moist air.

(iii) Incompatibilities: Ammonium nitrate, fused: Reacts violently or explosively with cadmium dust below 20°C. Hydrozoic acid: Violent explosion occurs after thirty minutes. Acids: Reacts violently, forms hydrogen gas. Oxidizing agents or metals:

Strong reaction with cadmium dust. Nitryl fluoride at slightly elevated temperature: Glowing or white incandescence occurs. Selenium: Reacts exothermically. Ammonia: Corrosive reaction. Sulfur dioxide: Corrosive reaction. Fire extinguishing agents (water, foam, carbon dioxide, and halons): Reacts violently. Tellurium: Incandescent reaction in hydrogen atmosphere.

(iv) Hazardous decomposition products: The heated metal rapidly forms highly toxic, brownish fumes of oxides of cadmium.

(c) Spill, leak, and disposal procedures.

(i) Steps to be taken if the materials is released or spilled. Do not touch spilled material. Stop leak if you can do it without risk. Do not get water inside container. For large spills, dike spill for later disposal. Keep unnecessary people away. Isolate hazard area and deny entry.

(ii) The Superfund Amendments and Reauthorization Act of 1986 Section 304 requires that a release equal to or greater than the reportable quantity for this substance (one pound) must be immediately reported to the local emergency planning committee, the state emergency response commission, and the National Response Center (800) 424-8802; in Washington, DC metropolitan area (202) 426-2675.

(2) **Cadmium oxide.**

(a) Physical and chemical date.

(i) Substance identification.

Chemical name: Cadmium oxide.

Formula: CdO.

Molecular Weight: 128.4.

CAS No.: 1306-19-0.

Other identifiers: RTECS EV1929500.

Synonyms: Kadmu tlenek (Polish).

(ii) Physical data.

Boiling point (760 mm Hg): 950 degrees C decomposes.

Melting point: 1500°C.

Specific gravity: (H_2O = 1@20°C): 7.0.

Solubility: Insoluble in water; soluble in acids and alkalines.

Appearance: Red or brown crystals.

WAC 296-62-07443 (Cont.)

(b) Fire, explosion, and reactivity data.

(i) Fire.

Fire and explosion hazards: Negligible fire hazard when exposed to heat or flame.

Flash point: Nonflammable.

Extinguishing media: Dry chemical, carbon dioxide, water spray or foam.

(ii) Reactivity.

Conditions contributing to instability: Stable under normal temperatures and pressures.

(iii) Incompatibilities: Magnesium may reduce CdO2 explosively on heating.

(iv) Hazardous decomposition products: Toxic fumes of cadmium.

(c) Spill, leak, and disposal procedures.

(i) Steps to be taken if the material is released or spilled. Do not touch spilled material. Stop leak if you can do it without risk. For small spills, take up with sand or other absorbent material and place into containers for later disposal. For small dry spills, use a clean shovel to place material into clean, dry container and then cover. Move containers from spill area. For larger spills, dike far ahead of spill for later disposal. Keep unnecessary people away. Isolate hazard area and deny entry.

(ii) The Superfund Amendments and Reauthorization Act of 1986 Section 304 requires that a release equal to or greater than the reportable quantity for this substance (one pound) must be immediately reported to the local emergency planning committee, the state emergency response commission, and the National Response Center (800) 424-8802; in Washington, DC metropolitan area (202) 426-2675.

(3) **Cadmium sulfide.**

(a) Physical and chemical data.

(i) Substance identification.

Chemical name: Cadmium sulfide.

Formula: CdS.

Molecular weight: 144.5.

CAS No. 1306-23-6.

Other identifiers: RTECS EV3150000.

Synonyms: Aurora yellow; Cadmium Golden 366; Cadmium Lemon Yellow 527; Cadmium Orange; Cadmium Primrose 819; Cadmium Sulphide; Cadmium Yellow; Cadmium Yellow 000; Cadmium Yellow Conc. Deep; Cadmium Yellow Conc.

WAC 296-62-07443 (Cont.)

Golden; Cadmium Yellow Conc. Lemon; Cadmium Yellow Conc. Primrose; Cadmium Yellow Oz. Dark; Cadmium Yellow Primrose 47-1400; Cadmium Yellow 10G Conc.; Cadmium Yellow 892; Cadmopur Golden Yellow N; Cadmopur Yellow: Capsebon; C.I. 77199; C.I. Pigment Orange 20; CI Pigment Yellow 37; Ferro Lemon Yellow; Ferro Orange Yellow; Ferro Yellow; Greenockite; NCI-C02711.

(ii) Physical data.

Boiling point (760 mm. Hg): sublines in N2 at 980°C.

Melting point: 1750 degrees C (100 atm).

Specific gravity: (H_2O = 1@ 20°C): 4.82.

Solubility: Slightly soluble in water; soluble in acid.

Appearance: Light yellow or yellow-orange crystals.

(b) Fire, explosion, and reactivity data.

(i) Fire.

Fire and explosion hazards: Negligible fire hazard when exposed to heat or flame.

Flash point: Nonflammable.

Extinguishing media: Dry chemical, carbon dioxide, water spray or foam.

(ii) Reactivity. Conditions contributing to instability: Generally nonreactive under normal conditions. Reacts with acids to form toxic hydrogen sulfide gas.

(iii) Incompatibilities: Reacts vigorously with iodinemonochloride.

(iv) Hazardous decomposition products: Toxic fumes of cadmium and sulfur oxides.

(c) Spill, leak, and disposal procedures.

(i) Steps to be taken if the material is released or spilled. Do not touch spilled material. Stop leak if you can do it without risk. For small, dry spills, with a clean shovel place material into clean, dry container and cover. Move containers from spill area.

(ii) For larger spills, dike far ahead of spill for later disposal. Keep unnecessary people away. Isolate hazard and deny entry.

(4) **Cadmium chloride.**

(a) Physical and chemical data.

(i) Substance identification.

Chemical name: Cadmium chloride.

Formula: CdC12.

WAC 296-62-07443 (Cont.)

Molecular weight: 183.3.

CAS No. 10108-64-2.

Other identifiers: RTECS EY0175000.

Synonyms: Caddy; Cadmium dichloride; NA 2570 (DOT); UI-CAD; dichlorocadmium.

(ii) Physical data.

Boiling point (760 mm Hg): 960 degrees C.

Melting point: 568 degrees C.

Specific gravity: (H_2O = 1 @ 20°C): 4.05.

Solubility: Soluble in water (140 g/100 cc); soluble in acetone.

Appearance: Small, white crystals.

(b) Fire, explosion, and reactivity data.

(i) Fire.

Fire and explosion hazards: Negligible fire and negligible explosion hazard in dust form when exposed to heat or flame.

Flash point: Nonflammable.

Extinguishing media: Dry chemical, carbon dioxide, water spray, or foam.

(ii) Reactivity. Conditions contributing to instability: Generally stable under normal temperatures and pressures.

(iii) Incompatibilities: Bromine triflouride [trifluoride] rapidly attacks cadmium chloride. A mixture of potassium and cadmium chloride may produce a strong explosion on impact.

(iv) Hazardous decomposition products: Thermal decomposition may release toxic fumes of hydrogen chloride, chloride, chlorine or oxides of cadmium.

(c) Spill, leak, and disposal procedures.

(i) Steps to be taken if the materials is released or spilled. Do not touch spilled material. Stop leak if you can do it without risk. For small, dry spills, with a clean shovel place material into clean, dry container and cover. Move containers from spill area. For larger spills, dike far ahead of spill for later disposal. Keep unnecessary people away. Isolate hazard and deny entry.

(ii) The Superfund Amendments and Reauthorization Act of 1986 Section 304 requires that a release equal to or greater than the reportable quantity for this substance (one hundred pounds) must be immediately reported to the local emergency planning committee, the state emergency response commission, and the National Response Center (800) 424-8802; in Washington, DC Metropolitan area (202) 426-2675.

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07443, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07447 Appendix D--Occupational health history interview with reference to cadmium exposure directions.

(To be read by employee and signed prior to the interview.)

Please answer the questions you will be asked as completely and carefully as you can. These questions are asked of everyone who works with cadmium. You will also be asked to give blood and urine samples. The doctor will give your employer a written opinion on whether you are physically capable of working with cadmium. Legally, the doctor cannot share personal information you may tell him/her with your employer. The following information is considered strictly confidential. The results of the tests will go to you, your doctor and your employer. You will also receive an information sheet explaining the results of any biological monitoring or physical examinations performed. If you are just being hired, the results of this interview and examination will be used to:

(1) Establish your health status and see if working with cadmium might be expected to cause unusual problems;

(2) Determine your health status today and see if there are changes over time;

(3) See if you can wear a respirator safely. If you are not a new hire: WISHA says that everyone who works with cadmium can have periodic medical examinations performed by a doctor. The reasons for this are:

(a) If there are changes in your health, either because of cadmium or some other reason, to find them early;

(b) To prevent kidney damage.

Please sign below.
I have read these directions and understand them:

_____
Employee signature

_____
Date

Thank you for answering these questions. (Suggested Format)
Name:_____
Age:_____
Social Security #:_____
Company:_____Job:_____
Type of Preplacement Exam: [ ] Periodic [ ] Termination [ ] Initial [ ] Other
Blood Pressure:_____Pulse Rate:_____

1. How long have you worked at the job listed above?
   [ ] Not yet hired [ ] Number of months [ ] Number of years
2. Job Duties etc._____
   _____
3. Have you ever been told by a doctor that you had bronchitis? [ ] Yes [ ] No
   If yes, how long ago? [ ] Number of months [ ] Number of years
4. Have you ever been told by a doctor that you had emphysema? [ ] Yes [ ] No
   If yes, how long ago? [ ] Number of years [ ] Number of months
5. Have you ever been told by a doctor that you had other lung problems? [ ] Yes [ ] No
   If yes, please describe type of lung problems and when you had these problems: _____
   _____
   _____
6. In the past year, have you had a cough? [ ] Yes [ ] No
   If yes, did you cough up sputum? [ ] Yes [ ] No
   If yes, how long did the cough with sputum production last? [ ] Less than 3 months [ ] 3 months or longer
   If yes, for how many years have you had episodes of cough with sputum production lasting this long? [ ] Less than one [ ] 1 [ ] 2 [ ] Longer than 2

WAC 296-62-07447 (Cont.)

7. Have you ever smoked cigarettes? [ ] Yes [ ] No
8. Do you now smoke cigarettes? [ ] Yes [ ] No
9. If you smoke or have smoked cigarettes, for how many years have you smoked, or did you smoke?
   [ ] Less than 1 year [ ] Number of years
   What is or was the greatest number of packs per day that you have smoked? [ ] Number of packs
   If you quit smoking cigarettes, how many years ago did you quit?
   [ ] Less than 1 year [ ] Number of years
   How many packs a day do you now smoke? [ ] Number of packs per day
10. Have you ever been told by a doctor that you had a kidney or urinary tract disease or disorder?
    [ ] Yes [ ] No
11. Have you ever had any of these disorders?

Kidney stones	[ ] Yes [ ] No
Protein in urine	[ ] Yes [ ] No
Blood in urine	[ ] Yes [ ] No
Difficulty urinating	[ ] Yes [ ] No
Other kidney/Urinary disorders	[ ] Yes [ ] No

Please describe problems, age, treatment, and follow up for any kidney or urinary problems you have had:
_____
_____
_____

12. Have you ever been told by a doctor or other health care provider who took your blood pressure that your blood pressure was high? [ ] Yes [ ] No
13 Have you ever been advised to take any blood pressure medication? [ ] Yes [ ] No
14. Are you presently taking any blood pressure medication? [ ] Yes [ ] No
15. Are you presently taking any other medication? [ ] Yes [ ] No
16. Please list any blood pressure or other medications and describe how long you have been taking each one:
    Medicine:_____
    _____
    _____
    How Long Taken:_____
17. Have you ever been told by a doctor that you have diabetes? (sugar in your blood or urine)
    [ ] Yes [ ] No
    If yes, do you presently see a doctor about your diabetes? [ ] Yes [ ] No
    If yes, how do you control your blood sugar? [ ] Diet alone [ ] Diet
    plus oral medicine [ ] Diet plus insulin (injection)
18. Have you ever been told by a doctor that you had:
    Anemia ? [ ] Yes [ ] No
    A low blood count? [ ] Yes [ ] No
19. Do you presently feel that you tire or run out of energy sooner than normal or sooner than other people your age? [ ] Yes [ ] No
    If yes, for how long have you felt that you tire easily? [ ] Less than 1 year [ ] Number of years
20. Have you given blood within the last year? [ ] Yes [ ] No
    If yes, how many times? [ ] Number of times
    How long ago was the last time you gave blood? [ ] Less than 1 month [ ] Number of months
21. Within the last year have you had any injuries with heavy bleeding? [ ] Yes [ ] No
    If yes, how long ago? [ ] Less than 1 month [ ] Number of months describe:
22. Have you recently had any surgery? [ ] Yes [ ] No If yes, please describe:_____
    _____
    _____
23. Have you seen any blood lately in your stool or after a bowel movement? [ ] Yes [ ] No

WAC 296-62-07447 (Cont.)

24. Have you ever had a test for blood in your stool? [ ] Yes [ ] No
If yes, did the test show any blood in the stool? [ ] Yes [ ] No
What further evaluation and treatment were done?_____
_____
_____

The following questions pertain to the ability to wear a respirator. Additional information for the physician can be found in The Respiratory Protective Devices Manual.

25. Have you ever been told by a doctor that you have asthma? [ ] Yes [ ] No
If yes, are you presently taking any medication for asthma?
Mark all that apply. [ ] Shots [ ] Pills [ ] Inhaler
26. Have you ever had a heart attack? [ ] Yes [ ] No
If yes, how long ago? [ ] Number of years [ ] Number of months
27. Have you ever had pains in your chest? [ ] Yes [ ] No
If yes, when did it usually happen?
[ ] While resting [ ] While working [ ] While exercising [ ] Activity didn't matter
28. Have you ever had a thyroid problem? [ ] Yes [ ] No
29. Have you ever had a seizure or fits? [ ] Yes [ ] No
30. Have you ever had a stroke (cerebrovascular accident)? [ ] Yes [ ] No
31. Have you ever had a ruptured eardrum or a serious hearing problem? [ ] Yes [ ] No
32. Do you now have a claustrophobia, meaning fear of crowded or closed in spaces or any psychological problems that would make it hard for you to wear a respirator? [ ] Yes [ ] No

The following questions pertain to reproductive history.

33. Have you or your partner had a problem conceiving a child? [ ] Yes [ ] No
If yes, specify: [ ] Self [ ] Present mate [ ] Previous mate
34. Have you or your partner consulted a physician for a fertility or other reproductive problem?
[ ] Yes [ ] No
If yes, specify who consulted the physician: [ ] Self [ ] Spouse/partner [ ] Self and partner
If yes, specify diagnosis made:_____
_____
35. Have you or your partner ever conceived a child resulting in a miscarriage, still birth or deformed offspring? [ ] Yes [ ] No
If yes, specify: [ ] Miscarriage [ ] Still birth [ ] Deformed offspring
If outcome was a deformed offspring, please specify
type:_____
_____
_____
36. Was this outcome a result of a pregnancy of: [ ] Yours with present partner [ ] Yours with a previous partner
37. Did the timing of any abnormal pregnancy outcome coincide with present employment?
[ ] Yes [ ] No List dates of
occurrences:_____
_____
_____
38. What is the occupation of your spouse or partner?
_____
_____
_____

For Women Only

39. Do you have menstrual periods? [ ] Yes [ ] No
Have you had menstrual irregularities? [ ] Yes [ ] No
If yes, specify type:_____
If yes, what was the approximated date this problem began?_____
Approximate date problem stopped?_____

WAC 296-62-07447 (Cont.)

For Men Only

40. Have you ever been diagnosed by a physician as having prostate gland problem(s)? [ ] Yes [ ] No
If yes, please describe type of problem(s) and what was done to evaluate and treat the problem(s):
_____
_____

[Statutory Authority: Chapter 49.17 RCW. 93-21-075 (Order 93-06), § 296-62-07447, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07447, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07449 Appendix E--Cadmium in workplace atmospheres.

Method number: ID-189 (OSHA); (ICP/MS) 0009 (WISHA)

Matrix: Air

WISHA permissible exposure limits: 5 µg/m^3 (TWA), 2.5 µg/m^3 (action level TWA)

Collection procedure: A known volume of air is drawn through a 37-mm diameter filter cassette containing a 0.8 µm mixed cellulose ester membrane filter (MCEF).

Recommended air volume: 960 L

Recommended sampling rate: 2.0 L/min

Analytical procedure: Air filter samples are digested with nitric acid. After digestion, a small amount of hydrochloric acid is added. The samples are then diluted to volume with deionized water and analyzed by either flame atomic absorption spectroscopy (AAS) or flameless atomic absorption spectroscopy using a heated graphite furnace atomizer (AAS-HGA).

Detection limits:

Qualitative: 0.2 µg/m^3 for a 200 L sample by Flame AAS, 0.007 µg/m^3 for a 60 L sample by AAS-HGA

Quantitative: 0.70 µg/m^3 for a 200 L sample by Flame AAS, 0.025 µg/m^3 for a 60 L sample by AAS-HGA

Precision and accuracy: (Flame AAS Analysis and AAS-HGA Analysis):

Validation level: 2.5 to 10 µg/m^3 for a 400 L air vol, 1.25 to 5.0 µg/m^3 for a 60 L air vol CV_1 (pooled): 0.010, 0.043

Analytical bias: +4.0%, -5.8%

Overall analytical error: ±6.0%, ±14.2%

Method classification: Validated Date: June, 1992

Inorganic Service Branch II, OSHA Salt Lake Technical Center, Salt Lake City, Utah Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources can be substituted.

(1) **Introduction.**

(a) Scope.

WAC 296-62-07449 (Cont.)

This method describes the collection of airborne elemental cadmium and cadmium compounds on 0.8 µm mixed cellulose ester membrane filters and their subsequent analysis by either flame atomic absorption spectroscopy (AAS) or flameless atomic absorption spectroscopy using a heated graphite furnace atomizer (AAS-HGA). It is applicable for both TWA and action level TWA permissible exposure level (PEL) measurements. The two atomic absorption analytical techniques included in the method do not differentiate between cadmium fume and cadmium dust samples. They also do not differentiate between elemental cadmium and its compounds.

(b) Principle.

Airborne elemental cadmium and cadmium compounds are collected on a 0.8 µm mixed cellulose ester membrane filter (MCEF). The air filter samples are digested with concentrated nitric acid to destroy the organic matrix and dissolve the cadmium analytes. After digestion, a small amount of concentrated hydrochloric acid is added to help dissolve other metals which may be present. The samples are diluted to volume with deionized water and then aspirated into the oxidizing air/acetylene flame of an atomic absorption spectrophotometer for analysis of elemental cadmium. If the concentration of cadmium in a sample solution is too low for quantitation by this flame AAS analytical technique, and the sample is to be averaged with other samples for TWA calculations, aliquots of the sample and a matrix modifier are later injected onto a L'vov platform in a pyrolytically-coated graphite tube of a Zeeman atomic absorption spectrophotometer/graphite furnace assembly for analysis of elemental cadmium. The matrix modifier is added to stabilize the cadmium metal and minimize sodium chloride as an interference during the high temperature charring step of the analysis subsection (5)(a) and (b) of this section.

(c) History.

Previously, two OSHA sampling and analytical methods for cadmium were used concurrently WAC 296-62-07449 (5)(c) and (d). Both of these methods also required 0.8 µm mixed cellulose ester membrane filters for the collection of air samples. These cadmium air filter samples were analyzed by either flame atomic absorption spectroscopy (subsection (5)(c) of this section) or inductively coupled plasma/atomic emission spectroscopy (ICP-AES) (subsection (5)(d) of this section). Neither of these two analytical methods have adequate sensitivity for measuring workplace exposure to airborne cadmium at the new lower TWA and action level TWA PEL levels when consecutive samples are taken on one employee and the sample results need to be averaged with other samples to determine a single TWA. The inclusion of two atomic absorption analytical techniques in the new sampling and analysis method for airborne cadmium permits quantitation of sample results over a broad range of exposure levels and sampling periods. The flame AAS analytical technique included in this method is similar to the previous procedure given in the General Metals Method ID-121 (subsection (5)(c) of this section) with some modifications. The sensitivity of the AAS-HGA analytical technique included in this method is adequate to measure exposure levels at 1/10 the action level TWA, or lower, when less than full-shift samples need to be averaged together.

(d) Properties (subsection (5)(e) of this section).

Elemental cadmium is a silver-white, blue-tinged, lustrous metal which is easily cut with a knife. It is slowly oxidized by moist air to form cadmium oxide. It is insoluble in water, but reacts readily with dilute nitric acid. Some of the physical properties and other descriptive information of elemental cadmium are given below:

WAC 296-62-07449 (Cont.)

CAS No	7440-43-9
Atomic Number	48
Atomic Symbol	Cd
Atomic Weight	112.41
Melting Point	321°C
Boiling Point	765°C
Density	8.65 g/mL (25°C)

The properties of specific cadmium compounds are described in reference subsection (5)(e) of this section.

(e) Method performance.

A synopsis of method performance is presented below. Further information can be found in subsection (4) of this section.

(i) The qualitative and quantitative detection limits for the flame AAS analytical technique are 0.04 µg (0.004 µg/mL) and 0.14 µg (0.014 µg/mL) cadmium, respectively, for a 10 mL solution volume. These correspond, respectively, to 0.2 $\mu g/m^3$ and 0.70 $\mu g/m^3$ for a 200 L air volume.

(ii) The qualitative and quantitative detection limits for the AAS-HGA analytical technique are 0.44 ng (0.044 ng/mL) and 1.5 ng (0.15 ng/mL) cadmium, respectively, for a 10 mL solution volume. These correspond, respectively, to 0.007 $\mu g/m^3$ and 0.025 $\mu g/m^3$ for a 60 L air volume.

(iii) The average recovery by the flame AAS analytical technique of 17 spiked MCEF samples containing cadmium in the range of 0.5 to 2.0 times the TWA target concentration of 5 $\mu g/m^3$ (assuming a 400 L air volume) was 104.0% with a pooled coefficient of variation (CV_1) of 0.010. The flame analytical technique exhibited a positive bias of +4.0% for the validated concentration range. The overall analytical error (OAE) for the flame AAS analytical technique was ±6.0%.

(iv) The average recovery by the AAS-HGA analytical technique of 18 spiked MCEF samples containing cadmium in the range of 0.5 to 2.0 times the action level TWA target concentration of 2.5 $\mu g/m^3$ (assuming a 60 L air volume) was 94.2% with a pooled coefficient of variation (CV_1) of 0.043. The AAS-HGA analytical technique exhibited a negative bias of -5.8% for the validated concentration range. The overall analytical error (OAE) for the AAS-HGA analytical technique was ±14.2%.

(v) Sensitivity in flame atomic absorption is defined as the characteristic concentration of an element required to produce a signal of 1% absorbance (0.0044 absorbance units). Sensitivity values are listed for each element by the atomic absorption spectrophotometer manufacturer and have proved to be a very valuable diagnostic tool to determine if instrumental parameters are optimized and if the instrument is performing up to specification. The sensitivity of the spectrophotometer used in the validation of the flame AAS analytical technique agreed with the manufacturer specifications (subsection (5)(f) of this section); the 2 µg/mL cadmium standard gave an absorbance reading of 0.350 abs. units.

(vi) Sensitivity in graphite furnace atomic absorption is defined in terms of the characteristic mass, the number of picograms required to give an integrated absorbance value of 0.0044 absorbance-second (subsection (5)(g) of this section). Data suggests that under stabilized temperature platform furnace (STPF) conditions (see (f)(ii) of this subsection),

characteristic mass values are transferable between properly functioning instruments to an accuracy of about twenty percent (subsection (5)(b) of this section). The characteristic mass for STPF analysis of cadmium with Zeeman background correction listed by the manufacturer of the instrument used in the validation of the AAS-HGA analytical technique was 0.35 pg. The experimental characteristic mass value observed during the determination of the working range and detection limits of the AAS-HGA analytical technique was 0.41 pg.

(f) Interferences.

(i) High concentrations of silicate interfere in determining cadmium by flame AAS (subsection (5)(f) of this section). However, silicates are not significantly soluble in the acid matrix used to prepare the samples.

(ii) Interferences, such as background absorption, are reduced to a minimum in the AAS-HGA analytical technique by taking full advantage of the stabilized temperature platform furnace (STPF) concept. STPF includes all of the following parameters (subsection (5)(b) of this section):

(A) Integrated absorbance;

(B) Fast instrument electronics and sampling frequency;

(C) Background correction;

(D) Maximum power heating;

(E) Atomization off the L'vov platform in a pyrolytically coated graphite tube;

(F) Gas stop during atomization;

(G) Use of matrix modifiers.

(g) Toxicology (subsection (5)(n) of this section).

Information listed within this section is synopsis of current knowledge of the physiological effects of cadmium and is not intended to be used as the basis for WISHA policy. IARC classifies cadmium and certain of its compounds as Group 2A carcinogens (probably carcinogenic to humans). Cadmium fume is intensely irritating to the respiratory tract. Workplace exposure to cadmium can cause both chronic and acute effects. Acute effects include tracheobronchitis, pneumonitis, and pulmonary edema. Chronic effects include anemia, rhinitis/anosmia, pulmonary emphysema, proteinuria and lung cancer. The primary target organs for chronic disease are the kidneys (noncarcinogenic) and the lungs (carcinogenic).

(2) **Sampling.**

(a) Apparatus.

(i) Filter cassette unit for air sampling: A 37-mm diameter mixed cellulose ester membrane filter with a pore size of 0.8 µm contained in a 37-mm polystyrene two- or three-piece cassette filter holder (part no. MAWP 037 A0, Millipore Corp., Bedford, MA). The filter is supported with a cellulose backup pad. The cassette is sealed prior to use with a shrinkable gel band.

WAC 296-62-07449 (Cont.)

(ii) A calibrated personal sampling pump whose flow is determined to an accuracy of ±5% at the recommended flow rate with the filter cassette unit in line.

(b) Procedure

(i) Attach the prepared cassette to the calibrated sampling pump (the backup pad should face the pump) using flexible tubing. Place the sampling device on the employee such that air is sampled from the breathing zone.

(ii) Collect air samples at a flow rate of 2.0 L/min. If the filter does not become overloaded, a full-shift (at least seven hours) sample is strongly recommended for TWA and action level TWA measurements with a maximum air volume of 960 L. If overloading occurs, collect consecutive air samples for shorter sampling periods to cover the full workshift.

(iii) Replace the end plugs into the filter cassettes immediately after sampling. Record the sampling conditions.

(iv) Securely wrap each sample filter cassette end-to-end with a sample seal.

(v) Submit at least one blank sample. With each set of air samples. The blank sample should be handled the same as the other samples except that no air is drawn through it.

(vi) Ship the samples to the laboratory for analysis as soon as possible in a suitable container designed to prevent damage in transit.

(3) **Analysis.**

(a) Safety precautions.

(i) Wear safety glasses, protective clothing and gloves at all times.

(ii) Handle acid solutions with care. Handle all cadmium samples and solutions with extra care (see subsection (1)(g) of this section). Avoid their direct contact with work area surfaces, eyes, skin and clothes. Flush acid solutions which contact the skin or eyes with copious amounts of water.

(iii) Perform all acid digestions and acid dilutions in an exhaust hood while wearing a face shield. To avoid exposure to acid vapors, do not remove beakers containing concentrated acid solutions from the exhaust hood until they have returned to room temperature and have been diluted or emptied.

(iv) Exercise care when using laboratory glassware. Do not use chipped pipets, volumetric flasks, beakers or any glassware with sharp edges exposed in order to avoid the possibility of cuts or abrasions.

(v) Never pipet by mouth.

(vi) Refer to the instrument instruction manuals and SOPs (subsection (5)(h) and (i) of this section) for proper and safe operation of the atomic absorption spectrophotometer, raphite furnace atomizer and associated equipment.

(vii) Because metallic elements and other toxic substances are vaporized during AAS flame or graphite furnace atomizer operation, it is imperative that an exhaust vent be used. Always ensure that the exhaust system is operating properly during instrument use.

WAC 296-62-07449 (Cont.)

(b) Apparatus for sample and standard preparation.

(i) Hot plate, capable of reaching 150°C, installed in an exhaust hood.

(ii) Phillips beakers, 125 mL.

(iii) Bottles, narrow-mouth, polyethylene or glass with leakproof caps: used for storage of standards and matrix modifier.

(iv) Volumetric flasks, volumetric pipets, beakers and other associated general laboratory glassware.

(v) Forceps and other associated general laboratory equipment.

(c) Apparatus for flame AAS analysis.

(i) Atomic absorption spectrophotometer consisting of a(an):

Nebulizer and burner head; pressure regulating devices capable of maintaining constant oxidant and fuel pressures; optical system capable of isolating the desired wavelength of radiation (228.8 nm); adjustable slit; light measuring and amplifying device; display, strip chart, or computer interface for indicating the amount of absorbed radiation; cadmium hollow cathode lamp or electrodeless discharge lamp (EDL) and power supply.

(ii) Oxidant: Compressed air, filtered to remove water, oil and other foreign substances.

(iii) Fuel: Standard commercially available tanks of acetylene dissolved in acetone; tanks should be equipped with flash arresters.

Caution: *Do not use grades of acetylene containing solvents other than acetone because they may damage the PVC tubing used in some instruments.*

(iv) Pressure-reducing valves: Two gauge, two-stage pressure regulators to maintain fuel and oxidant pressures somewhat higher than the controlled operating pressures of the instrument.

(v) Exhaust vent installed directly above the spectrophotometer burner head.

(d) Apparatus for AAS-HGA analysis.

(i) Atomic absorption spectrophotometer consisting of a(an):

Heated graphite furnace atomizer (HGA) with argon purge system pressure-regulating devices capable of maintaining constant argon purge pressure; optical system capable of isolating the desired wavelength of radiation (228.8 nm); adjustable slit; light measuring and amplifying device; display, strip chart, or computer interface for indicating the amount of absorbed radiation (as integrated absorbance, peak area); background corrector: Zeeman or deuterium arc. The Zeeman background corrector is recommended; cadmium hollow cathode lamp or electrodeless discharge lamp (EDL) and power supply; autosampler capable of accurately injecting 5 to 20 µL sample aliquots onto the L'vov Platform in a graphite tube.

(ii) Pyrolytically coated graphite tubes containing solid, pyrolytic L'vov platforms.

WAC 296-62-07449 (Cont.)

(iii) Polyethylene sample cups, 2.0 to 2.5 mL, for use with the autosampler.

(iv) Inert purge gas for graphite furnace atomizer: Compressed gas cylinder of purified argon.

(v) Two gauge, two-stage pressure regulator for the argon gas cylinder.

(vi) Cooling water supply for graphite furnace atomizer.

(vii) Exhaust vent installed directly above the graphite furnace atomizer.

(e) Reagents. All reagents should be ACS analytical reagent grade or better.

(i) Deionized water with a specific conductance of less than 10 µS.

(ii) Concentrated nitric acid, HNO_3.

(iii) Concentrated hydrochloric acid, HCl.

(iv) Ammonium phosphate, monobasic, $NH_4H_2PO_4$.

(v) Magnesium nitrate, $Mg(NO_3)_2 * 6H_2O$.

(vi) Diluting solution (4% HNO_3, 0.4% HCl): Add 40 mL HNO_3 and 4 mL HCl carefully to approximately 500 mL deionized water and dilute to 1 L with deionized water.

(vii) Cadmium standard stock solution, 1,000 µg/mL: Use a commercially available certified 1,000 µg/mL cadmium standard or, alternatively, dissolve 1.0000 g of cadmium metal in a minimum volume of 1:1 HCl and dilute to 1 L with 4% HNO_3. Observe expiration dates of commercial standards. Properly dispose of commercial standards with no expiration dates or prepared standards one year after their receipt or preparation date.

(viii) Matrix modifier for AAS-HGA analysis: Dissolve 1.0 g $NH_4H_2PO_4$ and 0.15 g $Mg(NO_3)_2 * 6H_2O$ in approximately 200 mL deionized water. Add 1 mL HNO_3 and dilute to 500 mL with deionized water.

(ix) Nitric Acid, 1:1 HNO_3/DI H_2O mixture: Carefully add a measured volume of concentrated HNO_3 to an equal volume of DI H_2O.

(x) Nitric acid, 10% v/v: Carefully add 100 mL of concentrated HNO_3 to 500 mL of DI H_2O and dilute to 1 L.

(f) Glassware preparation.

(i) Clean Phillips beakers by refluxing with 1:1 nitric acid on a hot plate in a fume hood. Thoroughly rinse with deionized water and invert the beakers to allow them to drain dry.

(ii) Rinse volumetric flasks and all other glassware with 10% nitric acid and deionized water prior to use.

(g) Standard preparation for flame AAS analysis.

WAC 296-62-07449 (Cont.)

(i) Dilute stock solutions: Prepare 1, 5, 10 and 100 µg/mL cadmium standard stock solutions by making appropriate serial dilutions of 1,000 µg/mL cadmium standard stock solution with the diluting solution described in (e)(vi) of this subsection.

(ii) Working standards: Prepare cadmium working standards in the range of 0.02 to 2.0 µg/mL by making appropriate serial dilutions of the dilute stock solutions with the same diluting solution. A suggested method of preparation of the working standards is given below.

Working Standard (µg/mL)	Std Solution (µg/mL)	Aliquot (mL)	Final vol (mL)
0.02	1	10	500
0.05	5	5	500
0.1	10	5	500
0.2	10	10	500
0.5	10	25	500
1	100	5	500
2	100	10	500

Store the working standards in 500-mL, narrow-mouth polyethylene or glass bottles with leak proof caps. Prepare every twelve months.

(h) Standard preparation for AAS-HGA analysis.

(i) Dilute stock solutions: Prepare 10, 100 and 1,000 ng/mL cadmium standard stock solutions by making appropriate ten-fold serial dilutions of the 1,000 µg/mL cadmium standard stock solution with the diluting solution described in (e)(vi) of this subsection.

(ii) Working standards: Prepare cadmium working standards in the range of 0.2 to 20 ng/mL by making appropriate serial dilutions of the dilute stock solutions with the same diluting solution. A suggested method of preparation of the working standards is given below.

Working Standard (ng/mL)	Std Solution (ng/mL)	Aliquot (mL)	Final vol (mL)
0.2	10	2	100
0.5	10	5	100
1	10	10	100
2	100	2	100
5	100	5	100
10	100	10	100
20	1,000	2	100

Store the working standards in narrow-mouth polyethylene or glass bottles with leakproof caps. Prepare monthly.

(i) Sample preparation.

(i) Carefully transfer each sample filter with forceps from its filter cassette unit to a clean, separate 125-mL Phillips beaker along with any loose dust found in the cassette. Label each Phillips beaker with the appropriate sample number.

WAC 296-62-07449 (Cont.)

(ii) Digest the sample by adding 5 mL of concentrated nitric acid (HNO_3) to each Phillips beaker containing an air filter sample. Place the Phillips beakers on a hot plate in an exhaust hood and heat the samples until approximately 0.5 mL remains. The sample solution in each Phillips beaker should become clear. If it is not clear, digest the sample with another portion of concentrated nitric acid.

(iii) After completing the HNO_3 digestion and cooling the samples, add 40 µL (2 drops) of concentrated HCl to each air sample solution and then swirl the contents. Carefully add about 5 mL of deionized water by pouring it down the inside of each beaker.

(iv) Quantitatively transfer each cooled air sample solution from each Phillips beaker to a clean 10-mL volumetric flask. Dilute each flask to volume with deionized water and mix well.

(j) Flame AAS analysis.

Analyze all of the air samples for their cadmium content by flame atomic absorption spectroscopy (AAS) according to the instructions given below.

(i) Set up the atomic absorption spectrophotometer for the air/acetylene flame analysis of cadmium according to the SOP (subsection (5)(h) of this section) or the manufacturer's operational instructions. For the source lamp, use the cadmium hollow cathode or electrodeless discharge lamp operated at the manufacturer's recommended rating for continuous operation. Allow the lamp to warm up ten to twenty minutes or until the energy output stabilizes. Optimize conditions such as lamp position, burner head alignment, fuel and oxidant flow rates, etc. See the SOP or specific instrument manuals for details. Instrumental parameters for the Perkin-Elmer Model 603 used in the validation of this method are given in subsection (6) of this section.

(ii) Aspirate and measure the absorbance of a standard solution of cadmium. The standard concentration should be within the linear range. For the instrumentation used in the validation of this method a 2 µg/mL cadmium standard gives a net absorbance reading of about 0.350 abs. units (see subsection (1)(e)(v) of this section) when the instrument and the source lamp are performing to manufacturer specifications.

(iii) To increase instrument response, scale expand the absorbance reading of the aspirated 2 µg/mL working standard approximately four times. Increase the integration time to at least three seconds to reduce signal noise.

(iv) Autozero the instrument while aspirating a deionized water blank. Monitor the variation in the baseline absorbance reading (baseline noise) for a few minutes to insure that the instrument, source lamp and associated equipment are in good operating condition.

(v) Aspirate the working standards and samples directly into the flame and record their absorbance readings. Aspirate the deionized water blank immediately after every standard or sample to correct for and monitor any baseline drift and noise. Record the baseline absorbance reading of each deionized water blank. Label each standard and sample reading and its accompanying baseline reading.

(vi) It is recommended that the entire series of working standards be analyzed at the beginning and end of the analysis of a set of samples to establish a concentration-response curve, ensure that the standard readings agree with each other and are reproducible. Also, analyze a working standard after every five or six samples to monitor the performance of the spectrophotometer. Standard readings should agree within ±10 to 15% of the readings obtained at the beginning of the analysis.

WAC 296-62-07449 (Cont.)

(vii) Bracket the sample readings with standards during the analysis. If the absorbance reading of a sample is above the absorbance reading of the highest working standard, dilute the sample with diluting solution and reanalyze. Use the appropriate dilution factor in the calculations.

(viii) Repeat the analysis of approximately ten percent of the samples for a check of precision.

(ix) If possible, analyze quality control samples from an independent source as a check on analytical recovery and precision.

(x) Record the final instrument settings at the end of the analysis. Date and label the output.

(k) AAS-HGA analysis.

Initially analyze all of the air samples for their cadmium content by flame atomic absorption spectroscopy (AAS) according to the instructions given in (j) of this subsection. If the concentration of cadmium in a sample solution is less than three times the quantitative detection limit (0.04 µg/mL (40 ng/mL) for the instrumentation used in the validation) and the sample results are to be averaged with other samples for TWA calculations, proceed with the AAS-HGA analysis of the sample as described below.

(i) Set up the atomic absorption spectrophotometer and HGA for flameless atomic absorption analysis of cadmium according to the SOP (subsection (5)(i) of this section) or the manufacturer's operational instructions and allow the instrument to stabilize. The graphite furnace atomizer is equipped with a pyrolytically coated graphite tube containing a pyrolytic platform. For the source lamp, use a cadmium hollow cathode or electrodeless discharge lamp operated at the manufacturer's recommended setting for graphite furnace operation. The Zeeman background corrector and EDL are recommended for use with the L'vov platform. Instrumental parameters for the Perkin-Elmer Model 5100 spectrophotometer and Zeeman HGA-600 graphite furnace used in the validation of this method are given in subsection (7) of this section.

(ii) Optimize the energy reading of the spectrophotometer at 228.8 nm by adjusting the lamp position and the wavelength according to the manufacturer's instructions.

(iii) Set up the autosampler to inject a 5-µL aliquot of the working standard, sample or reagent blank solution onto the L'vov platform along with a 10-µL overlay of the matrix modifier.

(iv) Analyze the reagent blank (diluting solution, (e)(vi) of this subsection) and then autozero the instrument before starting the analysis of a set of samples. It is recommended that the reagent blank be analyzed several times during the analysis to assure the integrated absorbance (peak area) reading remains at or near zero.

(v) Analyze a working standard approximately midway in the linear portion of the working standard range two or three times to check for reproducibility and sensitivity (see subsection (1)(e)(v) and (vi) of this section) before starting the analysis of samples. Calculate the experimental characteristic mass value from the average integrated absorbance reading and injection volume of the analyzed working standard. Compare this value to the manufacturer's suggested value as a check of proper instrument operation.

(vi) Analyze the reagent blank, working standard, and sample solutions. Record and label the peak area (abs-sec) readings and the peak and background peak profiles on the printer/plotter.

WAC 296-62-07449 (Cont.)

(vii) It is recommended the entire series of working standards be analyzed at the beginning and end of the analysis of a set of samples. Establish a concentration-response curve and ensure standard readings agree with each other and are reproducible. Also, analyze a working standard after every five or six samples to monitor the performance of the system. Standard readings should agree within ±15% of the readings obtained at the beginning of the analysis.

(viii) Bracket the sample readings with standards during the analysis. If the peak area reading of a sample is above the peak area reading of the highest working standard, dilute the sample with the diluting solution and reanalyze. Use the appropriate dilution factor in the calculations.

(ix) Repeat the analysis of approximately ten percent of the samples for a check of precision.

(x) If possible, analyze quality control samples from an independent source as a check of analytical recovery and precision.

(xi) Record the final instrument settings at the end of the analysis. Date and label the output.

(l) Calculations.

Note: Standards used for HGA analysis are in ng/mL. Total amounts of cadmium from calculations will be in ng (not µg) unless a prior conversion is made.

(i) Correct for baseline drift and noise in flame AAS analysis by subtracting each baseline absorbance reading from its corresponding working standard or sample absorbance reading to obtain the net absorbance reading for each standard and sample.

(ii) Use a least squares regression program to plot a concentration-response curve of net absorbance reading (or peak area for HGA analysis) versus concentration (µg/mL or ng/mL) of cadmium in each working standard.

(iii) Determine the concentration (µg/mL or ng/mL) of cadmium in each sample from the resulting concentration-response curve. If the concentration of cadmium in a sample solution is less than three times the quantitative detection limit (0.04 µg/mL (40 ng/mL) for the instrumentation used in the validation of the method) and if consecutive samples were taken on one employee and the sample results are to be averaged with other samples to determine a single TWA, reanalyze the sample by

AAS-HGA as described in (k) of this subsection and report the AAS-HGA analytical results.

(iv) Calculate the total amount (µg or ng) of cadmium in each sample from the sample solution volume (mL):

W = (C)(sample vol, mL)(DF)

Where: W = Total cadmium in sample

C = Calculated concentration of cadmium

DF = Dilution Factor (if applicable)

WAC 296-62-07449 (Cont.)

(v) Make a blank correction for each air sample by subtracting the total amount of cadmium in the corresponding blank sample from the total amount of cadmium in the sample.

(vi) Calculate the concentration of cadmium in an air sample (mg/ m^3or µg/m^3) by using one of the following equations:

$mg/m^3 = W^{bc}/(\text{Air vol sampled, L})$

or

$\mu g/m^3 = (W^{bc})(1{,}000 \text{ ng}/\mu g)/(\text{Air vol sampled, L})$

Where: W^{bc} = blank corrected total µg cadmium in the sample.

(1µg = 1,000 ng)

(4) **Backup data.**

(a) Introduction.

(i) The purpose of this evaluation is to determine the analytical method recovery, working standard range, and qualitative and quantitative detection limits of the two atomic absorption analytical techniques included in this method. The evaluation consisted of the following experiments:

(A) An analysis of twenty-four samples (six samples each at 0.1, 0.5, 1 and 2 times the TWA-PEL) for the analytical method recovery study of the flame AAS analytical technique.

(B) An analysis of eighteen samples (six samples each at 0.5, 1 and 2 times the action level TWA-PEL) for the analytical method recovery study of the AAS-HGA analytical technique.

(C) Multiple analyses of the reagent blank and a series of standard solutions to determine the working standard range and the qualitative and quantitative detection limits for both atomic absorption analytical techniques.

(ii) The analytical method recovery results at all test levels were calculated from concentration-response curves and statistically examined for outliers at the ninety-nine percent confidence level. Possible outliers were determined using the Treatment of Outliers test (subsection (5)(j) of this section). In addition, the sample results of the two analytical techniques, at 0.5, 1.0 and 2.0 times their target concentrations, were tested for homogeneity of variances also at the ninety-nine percent confidence level. Homogeneity of the coefficients of variation was determined using the Bartlett's test (subsection (5)(k) of this section). The overall analytical error (OAE) at the ninety-five percent confidence level was calculated using the equation (subsection (5)(l) of this section):

$$OAE = \pm [\ |\text{Bias}|\ + (1.96)(CV_1 \text{ (pooled)})(100\%)]$$

(iii) A derivation of the International Union of Pure and Applied Chemistry (IUPAC) detection limit equation (subsection (5)(m) of this section) was used to determine the qualitative and quantitative detection limits for both atomic absorption analytical techniques:

WAC 296-62-07449 (Cont.)

$$C_{ld} = k(sd)/m \qquad \text{(Equation 1)}$$

Where: C_{ld} = the smallest reliable detectable concentration an analytical instrument can determine at a given confidence level.

k = 3 for the Qualitative Detection Limit at the 99.86% Confidence Level

k = 10 for the Quantitative Detection Limit at the 99.99% Confidence Level.

sd = standard deviation of the reagent blank (Rbl) readings.

m = analytical sensitivity or slope as calculated by linear regression.

(iv) Collection efficiencies of metallic fume and dust atmospheres on 0.8-µm mixed cellulose ester membrane filters are well documented and have been shown to be excellent (subsection (5)(k) of this section). Since elemental cadmium and the cadmium component of cadmium compounds are nonvolatile, stability studies of cadmium spiked MCEF samples were not performed.

(b) Equipment.

(i) A Perkin-Elmer (PE) Model 603 spectrophotometer equipped with a manual gas control system, a stainless steel nebulizer, a burner mixing chamber, a flow spoiler and a 10 cm (one-slot) burner head was used in the experimental validation of the flame AAS analytical technique. A PE cadmium hollow cathode lamp, operated at the manufacturer's recommended current setting for continuous operation (4 mA), was used as the source lamp. Instrument parameters are listed in subsection (6) of this section.

(ii) A PE Model 5100 spectrophotometer, Zeeman HGA-600 graphite furnace atomizer and AS-60 HGA autosampler were used in the experimental validation of the AAS-HGA analytical technique. The spectrophotometer was equipped with a PE Series 7700 professional computer and Model PR-310 printer. A PE System 2 cadmium electrodeless discharge lamp, operated at the manufacturer's recommended current setting for modulated operation (170 mA), was used as the source lamp. Instrument parameters are listed in subsection (7) of this section.

(c) Reagents.

(i) J.T. Baker Chem. Co. (Analyzed grade) concentrated nitric acid, 69.0-71.0%, and concentrated hydrochloric acid, 36.5-38.0%, were used to prepare the samples and standards.

(ii) Ammonium phosphate, monobasic, $NH_4H_2PO_4$ and magnesium nitrate hexahydrate, $Mg(NO_3)2.6\ H_2O$ both manufactured by the Mallinckrodt Chem. Co., were used to prepare the matrix modifier for AAS-HGA analysis.

(d) Standard preparation for flame AAS analysis.

(i) Dilute stock solutions: Prepared 0.01, 0.1, 1, 10 and 100 µg/mL cadmium standard stock solutions by making appropriate serial dilutions of a commercially available 1,000 µg/mL cadmium standard stock solution (RICCA Chemical Co., Lot# A102) with the diluting solution (4% HNO_3, 0.4% HCl).

WAC 296-62-07449 (Cont.)

(ii) Analyzed standards: Prepared cadmium standards in the range of 0.001 to 2.0 µg/mL by pipetting 2 to 10 mL of the appropriate dilute cadmium stock solution into a 100-mL volumetric flask and diluting to volume with the diluting solution. (See subsection (3)(g)(ii) of this section).

(e) Standard preparation for AAS-HGA analysis.

(i) Dilute stock solutions: Prepared 1, 10, 100 and 1,000 ng/mL cadmium standard stock solutions by making appropriate serial dilutions of a commercially available 1,000 µg/mL cadmium standard stock solution (J.T. Baker Chemical Co., Instra-analyzed, Lot# D22642) with the diluting solution (4% HNO_3, 0.4% HCl).

(ii) Analyzed standards: Prepared cadmium standards in the range of 0.1 to 40 ng/mL by pipetting 2 to 10 mL of the appropriate dilute cadmium stock solution into a 100-mL volumetric flask and diluting to volume with the diluting solution. (See subsection (3)(h)(ii) of this section).

(f) Detection limits and standard working range for flame AAS analysis.

(i) Analyzed the reagent blank solution and the entire series of cadmium standards in the range of 0.001 to 2.0 µg/mL three to six times according to the instructions given in subsection (3)(j) of this section. The diluting solution (4% HNO_3, 0.4% HCl) was used as the reagent blank. The integration time on the PE 603 spectrophotometer was set to 3.0 seconds and a four-fold expansion of the absorbance reading of the 2.0 µg/mL cadmium standard was made prior to analysis. The 2.0 µg/mL standard gave a net absorbance reading of 0.350 abs. units prior to expansion in agreement with the manufacturer's specifications (subsection (5)(f) of this section).

(ii) The net absorbance readings of the reagent blank and the low concentration Cd standards from 0.001 to 0.1 µg/mL and the statistical analysis of the results are shown in Table 1. The standard deviation, sd, of the six net absorbance readings of the reagent blank is 1.05 abs. units. The slope, m, as calculated by a linear regression plot of the net absorbance readings (shown in Table 2) of the 0.02 to 1.0 µg/mL cadmium standards versus their concentration is 772.7 abs. units/(µg/mL).

(iii) If these values for sd and the slope, m, are used in Eqn. 1 ((a)(ii) of this subsection), the qualitative and quantitative detection limits as determined by the IUPAC Method are:

C_{ld} = (3)(1.05 abs. units)/(772.7 abs. units/(µg/mL)) = 0.0041 µg/mL for the qualitative detection limit.

C_{ld} = (10)(1.05 abs. units)/(772.7 abs. units/(µg/mL)) = 0.014 µg/mL for the quantitative detection limit.

The qualitative and quantitative detection limits for the flame AAS analytical technique are 0.041 µg and 0.14 µg cadmium, respectively, for a 10 mL solution volume. These correspond, respectively, to 0.2 µg/m^3 and 0.70 µg/m^3 for a 200 L air volume.

(iv) The recommended Cd standard working range for flame AAS analysis is 0.02 to 2.0 µg/mL. The net absorbance readings of the reagent blank and the recommended working range standards and the statistical analysis of the results are shown in Table 2. The standard of lowest concentration in the working range, 0.02 µg/mL, is slightly greater than the calculated quantitative detection limit, 0.014 µg/mL. The standard of highest concentration in the working range, 2.0 µg/mL, is at the upper end of the linear working

range suggested by the manufacturer (subsection (5)(f) of this section). Although the standard net absorbance readings are not strictly linear at concentrations above 0.5 µg/mL, the deviation from linearity is only about ten percent at the upper end of the recommended standard working range. The deviation from linearity is probably caused by the four-fold expansion of the signal suggested in the method. As shown in Table 2, the precision of the standard net absorbance readings are excellent throughout the recommended working range; the relative standard deviations of the readings range from 0.009 to 0.064.

(g) Detection limits and standard working range for AAS-HGA analysis.

(i) Analyzed the reagent blank solution and the entire series of cadmium standards in the range of 0.1 to 40 ng/mL according to the instructions given in subsection (3)(k) of this section. The diluting solution (4% HNO_3, 0.4% HCl) was used as the reagent blank. A fresh aliquot of the reagent blank and of each standard was used for every analysis. The experimental characteristic mass value was 0.41 pg, calculated from the average peak area (abs-sec) reading of the 5 ng/mL standard which is approximately midway in the linear portion of the working standard range. This agreed within twenty percent with the characteristic mass value, 0.35 pg, listed by the manufacturer of the instrument (subsection (5)(b) of this section).

(ii) The peak area (abs-sec) readings of the reagent blank and the low concentration Cd standards from 0.1 to 2.0 ng/mL and statistical analysis of the results are shown in Table 3. Five of the reagent blank peak area readings were zero and the sixth reading was 1 and was an outlier. The near lack of a blank signal does not satisfy a strict interpretation of the IUPAC method for determining the detection limits. Therefore, the standard deviation of the six peak area readings of the 0.2 ng/mL cadmium standard, 0.75 abs-sec, was used to calculate the detection limits by the IUPAC method. The slope, m, as calculated by a linear regression plot of the peak area (abs-sec) readings (shown in Table 4) of the 0.2 to 10 ng/mL cadmium standards versus their concentration is 51.5 abs-sec/(ng/mL).

(iii) If 0.75 abs-sec (sd) and 51.5 abs-sec/(ng/mL) (m) are used in Eqn. 1 ((a)(iii) of this subsection), the qualitative and quantitative detection limits as determined by the IUPAC method are:

C_{ld} = (3)(0.75 abs-sec)/(51.5 abs-sec/(ng/mL) = 0.044 ng/mL for the qualitative detection limit.

C_{ld} = (10)(0.75 abs-sec)/(51.5 abs-sec/(ng/mL) = 0.15 ng/mL for the quantitative detection limit.

The qualitative and quantitative detection limits for the AAS-HGA analytical technique are 0.44 ng and 1.5 ng cadmium, respectively, for a 10 mL solution volume. These correspond, respectively, to 0.007 µg/m^3 and 0.025 µg/m^3 for a 60 L air volume.

(iv) The peak area (abs-sec) readings of the Cd standards from 0.2 to 40 ng/mL and the statistical analysis of the results are given in Table 4. The recommended standard working range for AAS-HGA analysis is 0.2 to 20 ng/mL. The standard of lowest concentration in the recommended working range is slightly greater than the calculated quantitative detection limit, 0.15 ng/mL. The deviation from linearity of the peak area readings of the 20 ng/mL standard, the highest concentration standard in the recommended working range, is approximately ten percent. The deviations from linearity of the peak area readings of the thirty and forty ng/mL standards are significantly greater than ten percent.

WAC 296-62-07449 (Cont.)

As shown in Table 4, the precision of the peak area readings are satisfactory throughout the recommended working range; the relative standard deviations of the readings range from 0.025 to 0.083.

(h) Analytical method recovery for flame AAS analysis.

(i) Four sets of spiked MCEF samples were prepared by injecting 20 µL of 10, 50, 100 and 200 µg/mL dilute cadmium stock solutions on 37 mm diameter filters (part No. AAWP 037 00, Millipore Corp., Bedford, MA) with a calibrated micropipet. The dilute stock solutions were prepared by making appropriate serial dilutions of a commercially available 1,000 µg/mL cadmium standard stock solution (RICCA Chemical Co., Lot # A102) with the diluting solution (4% HNO_3, 0.4% HCl). Each set contained six samples and a sample blank. The amount of cadmium in the prepared sets were equivalent to 0.1, 0.5, 1.0 and 2.0 times the TWA PEL target concentration of 5 $\mu g/m^3$ for a 400 L air volume.

(ii) The air-dried spiked filters were digested and analyzed for their cadmium content by flame atomic absorption spectroscopy (AAS) following the procedure described in subsection (3) of this section. The 0.02 to 2.0 µg/mL cadmium standards (the suggested working range) were used in the analysis of the spiked filters.

(iii) The results of the analysis are given in Table 5. One result at 0.5 times the TWA PEL target concentration was an outlier and was excluded from statistical analysis. Experimental justification for rejecting it is that the outlier value was probably due to a spiking error. The coefficients of variation for the three test levels at 0.5 to 2.0 times the TWA PEL target concentration passed the Bartlett's test and were pooled.

(iv) The average recovery of the six spiked filter samples at 0.1 times the TWA PEL target concentration was 118.2% with a coefficient of variation (CV_1) of 0.128. The average recovery of the spiked filter samples in the range of 0.5 to 2.0 times the TWA target concentration was 104.0% with a pooled coefficient of variation (CV_1) of 0.010. Consequently, the analytical bias found in these spiked sample results over the tested concentration range was +4.0% and the OAE was ±6.0%.

(i) Analytical method recovery for AAS-HGA analysis.

(i) Three sets of spiked MCEF samples were prepared by injecting 15 µL of 5, 10 and 20 µg/mL dilute cadmium stock solutions on 37 mm diameter filters (part no. AAWP 037 00, Millipore Corp., Bedford, MA) with a calibrated micropipet. The dilute stock solutions were prepared by making appropriate serial dilutions of a commercially available certified 1,000 µg/mL cadmium standard stock solution (Fisher Chemical Co., Lot# 913438-24) with the diluting solution (4% HNO_3, 0.4% HCl). Each set contained six samples and a sample blank. The amount of cadmium in the prepared sets were equivalent to 0.5, 1 and 2 times the action level TWA target concentration of 2.5 $\mu g/m^3$ for a 60 L air volume.

(ii) The air-dried spiked filters were digested and analyzed for their cadmium content by flameless atomic absorption spectroscopy using a heated graphite furnace atomizer following the procedure described in subsection (3) of this section. A five-fold dilution of the spiked filter samples at 2 times the action level TWA was made prior to their analysis. The 0.05 to 20 ng/mL cadmium standards were used in the analysis of the spiked filters.

WAC 296-62-07449 (Cont.)

(iii) The results of the analysis are given in Table 6. There were no outliers. The coefficients of variation for the three test levels at 0.5 to 2.0 times the action level TWA PEL passed the Bartlett's test and were pooled. The average recovery of the spiked filter samples was 94.2% with a pooled coefficient of variation (CV_1) of 0.043. Consequently, the analytical bias was -5.8% and the OAE was ±14.2%.

(j) Conclusions.

The experiments performed in this evaluation show the two atomic absorption analytical techniques included in this method to be precise and accurate and have sufficient sensitivity to measure airborne cadmium over a broad range of exposure levels and sampling periods.

(5) **References.**

(a) Slavin, W. Graphite Furnace AAS--A Source Book; Perkin-Elmer Corp., Spectroscopy Div.: Ridgefield, CT, 1984; p. 18 and pp. 83-90.

(b) Grosser, Z., Ed.; Techniques in Graphite Furnace Atomic Absorption Spectrophotometry; Perkin-Elmer Corp., Spectroscopy Div.: Ridgefield, CT, 1985.

(c) Occupational Safety and Health Administration Salt Lake Technical Center: Metal and Metalloid Particulate in Workplace Atmospheres (Atomic Absorption) (USDOL/OSHA Method No. ID-121). In OSHA Analytical Methods Manual 2nd ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1991.

(d) Occupational Safety and Health Administration Salt Lake Technical Center: Metal and Metalloid Particulate in Workplace Atmospheres (ICP) (USDOL/OSHA Method No. ID-125G). In OSHA Analytical Methods Manual 2nd ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1991.

(e) Windholz, M., Ed.; The Merck Index, 10th ed.; Merck & Co.: Rahway, NJ, 1983.

(f) Analytical Methods for Atomic Absorption Spectrophotometry, The Perkin-Elmer Corporation: Norwalk, CT, 1982.

(g) Slavin, W., D.C. Manning, G. Carnrick, and E. Pruszkowska: Properties of the Cadmium Determination with the Platform Furnace and Zeeman Background Correction. Spectrochim. Acta 38B:1157-1170 (1983).

(h) Occupational Safety and Health Administration Salt Lake Technical Center: Standard Operating Procedure for Atomic Absorption. Salt Lake City, UT: USDOL/OSHA-SLTC, In progress.

(i) Occupational Safety and Health Administration Salt Lake Technical Center: AAS-HGA Standard Operating Procedure. Salt Lake City, UT: USDOL/OSHA- SLTC, In progress.

(j) Mandel, J.: Accuracy and Precision, Evaluation and Interpretation of Analytical Results, The Treatment of Outliers. In Treatise On Analytical Chemistry, 2nd ed., Vol.1, edited by I. M. Kolthoff and P. J. Elving. New York: John Wiley and Sons, 1978. pp. 282-285.

(k) National Institute for Occupational Safety and Health: Documentation of the NIOSH Validation Tests by D. Taylor, R. Kupel, and J. Bryant (DHEW/NIOSH Pub. No. 77-185). Cincinnati, OH: National Institute for Occupational Safety and Health, 1977.

WAC 296-62-07449 (Cont.)

(l) Occupational Safety and Health Administration Analytical Laboratory: Precision and Accuracy Data Protocol for Laboratory Validations. In OSHA Analytical Methods Manual 1st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists (Pub. No. ISBN: 0-936712-66-X), 1985.

(m) Long, G.L. and J.D. Winefordner: Limit of Detection--A Closer Look at the IUPAC Definition. Anal. Chem. 55:712A-724A (1983).

(n) American Conference of Governmental Industrial Hygienists: Documentation of Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.

WAC 296-62-07449 (Cont.)

Table 1-Cd Detection Limit Study [Flame AAS Analysis]			
STD (µg/mL)	Absorbance reading at 228.8 nm		Statistical analysis
Reagent blank	5 4 4	2 3 3	n = 6. mean = 3.50. std dev = 1.05. CV = 0.30.
0.001	6 2 6	6 4 6	n = 6. mean = 5.00. std dev = 1.67. CV = 0.335.
0.002	5 7 7	7 3 4	n = 6. mean = 5.50. std dev = 1.76. CV =0 .320.
0.005	7 8 8	7 8 6	n = 6. mean = 7.33. std dev = 0.817. CV = 0.111.
0.010	10 10 10	9 13 10	n = 6. mean = 10.3. std dev = 1.37. CV = 0.133.
0.020	20 20 20	23 22 20	n = 6. mean = 20.8. std dev = 1.33. CV = 0.064.
0.050	42 42 42	42 42 45	n = 6. mean = 42.5. std dev = 1.22. CV = 0.029.
0.10		84 80 83	n = 3. mean = 82.3. std dev = 2.08. CV = 0.025.

WAC 296-62-07449 (Cont.)

Table 2--Cd Standard Working Range Study [Flame AAS Analysis]

STD (µg/mL)	Absorbance reading at 228.8 nm		Statistical analysis
Reagent blank	5 4 4	2 3 3	n = 6. mean = 3.50. std dev = 1.05. CV = 0.30.
0.020	20 20 20	23 22 20	n = 6. mean = 20.8. std dev = 1.33. CV = 0.064.
0.050	42 42 42	42 42 45	n = 6. mean = 42.5. std dev = 1.22. CV = 0.029.
0.10		84 80 83	n = 3. mean = 82.3. std dev = 2.08. CV = 0.025.
0.20		161 161 158	n = 3. mean = 160.0. std dev = 1.73. CV = 0.011.
0.50		391 389 393	n = 3. mean = 391.0. std dev = 2.00. CV = 0.005.
1.00		760 748 752	n = 3. mean = 753.3. std dev = 6.11. CV = 0.008.
2.00		1416 1426 1401	n = 3. mean = 1414.3. std dev = 12.6. CV = 0.009.

WAC 296-62-07449 (Cont.)

Table 3--Cd Detection Limit Study [AAS-HGA Analysis]

STD (ng/mL)	Peak area Readings x 10^3 at 228.8 nm		Statistical analysis
Reagent blank	0	0	n = 6.
	0	1	mean = 0.167.
	0	0	std dev = 0.41.
			CV = 2.45.
0.1	8	6	n = 6.
	5	7	mean = 7.7.
	13	7	std dev = 2.8.
			CV = 0.366.
0.2	11	13	n = 6.
	11	12	mean = 11.8.
	12	12	std dev = 0.75.
			CV = 0.064.
0.5	28	33	n = 6.
	26	28	mean = 28.8.
	28	30	std dev = 2.4.
			CV = 0.083.
1.0	52	55	n = 6.
	56	58	mean = 54.8.
	54	54	std dev = 2.0.
			CV = 0.037.
2.0	101	112	n = 6.
	110	110	mean = 108.8.
	110	110	std dev = 3.9.
			CV = 0.036.

WAC 296-62-07449 (Cont.)

Table 4--Cd Standard Working Range Study [AAS-HGA Analysis]

STD (ng/mL)	Peak area Readings x 10^3 at 228.8 nm		Statistical analysis
0.2	11 11 12	13 12 12	n = 6. mean = 11.8. std dev = 0.75. CV = 0.064.
0.5	28 26 28	33 28 30	n = 6. mean = 28.8. std dev = 2.4. CV = 0.083.
1.0	52 56 54	55 58 54	n = 6. mean = 54.8. std dev = 2.0. CV = 0.037.
2.0	101 110 110	112 110 110	n = 6. mean = 108.8. std dev = 3.9. CV = 0.036.
5.0	247 268 259	265 275 279	n = 6. mean = 265.5. std dev = 11.5. CV = 0.044.
10.0	495 523 516	520 513 533	n = 6. mean = 516.7. std dev = 12.7. CV = 0.025.
20.0	950 951 949	953 958 890	n = 6. mean = 941.8. std dev = 25.6. CV = 0.027.
30.0	1269 1303 1295	1291 1307 1290	n = 6. mean = 1293. std dev = 13.3. CV = 0.010.
40.0	1505 1535 1566	1567 1567 1572	n = 6. mean = 1552. std dev = 26.6. CV = 0.017.

WAC 296-62-07449 (Cont.)

Table 5--Analytical Method Recovery [Flame AAS Analysis]Test Level								
µg taken	**0.5x µg found**	**Percent rec.**	**µg taken**	**1.0x µg found**	**Percent rec.**	**µg taken**	**2.0x µg found**	**Percent rec.**
1.00	1.0715	107.2	2.00	2.0688	103.4		4.1504	103.8
1.00	1.0842	108.4	2.00	2.0174	100.9	4.00	4.1108	102.8
1.00	1.0842	108.4	2.00	2.0431	102.2	4.00	4.0581	101.5
1.00	*1.0081	*100.8	2.00	2.0431	102.2	4.00	4.0844	102.1
1.00	1.0715	107.2	2.00	2.0174	100.9	4.00	4.1504	103.8
1.00		108.4	2.00	2.0045	100.2	4.00	4.1899	104.7
						4.00		
n =	5			6			6	
mean =	107.9			101.6			103.1	
std dev =	0.657			1.174			1.199	
CV_1 =	0.006			0.011			0.012	

CV_1 (pooled) = 0.010

*Rejected as an outlier-this value did not pass the outlier T-test at the 99% confidence level.

Test Level 0.1x		
µg taken	**µg found**	**Percent rec.**
0.200	0.2509	125.5
0.200	0.2509	125.5
0.200	0.2761	138.1
0.200	0.2258	112.9
0.200	0.2258	112.9
0.200	0.1881	94.1

n =	6
mean =	118.2
std dev =	15.1
CV_1 =	0.128

WAC 296-62-07449 (Cont.)

Table 6-Analytical Method Recovery [AAS-HGA analysis] Test Level								
ng taken	**0.5x ng found**	**Percent rec.**	**ng taken**	**1.0x ng found**	**Percent rec.**	**ng taken**	**2.0x ng found**	**Percent rec.**
75	71.23	95.0	150	138.00	92.0	300	258.43	86.1
75	71.47	95.3	150	138.29	92.2	300	258.46	86.2
75	70.02	93.4	150	136.30	90.9	300	280.55	93.5
75	77.34	103.1	150	146.62	97.7	300	288.34	96.1
75	78.32	104.4	150	145.17	96.8	300	261.74	87.2
75	71.96	95.9.	150	144.88	96.6	300	277.22	92.4
n =	6			6			6	
mean =	97.9			94.4			90.3	
std dev =	4.66			2.98			4.30	
CV_1 =	0.048			0.032			0.048	

CV_1 (pooled) = 0.043

(6) Instrumental Parameters for Flame AAS Analysis
Atomic Absorption Spectrophotometer
(Perkin-Elmer Model 603)
Flame: Air/Acetylene--lean, blue
Oxidant Flow: 55
Fuel Flow: 32
Wavelength: 228.8 nm
Slit: 4 (0.7 nm)
Range: UV
Signal: Concentration (4 exp)
Integration Time: 3 sec

(7) Instrumental Parameters for HGA Analysis
Atomic Absorption Spectrophotometer
(Perkin-Elmer Model 5100)
Signal Type: Zeeman AA
Slitwidth: 0.7 nm
Wavelength: 228.8 nm
Measurement: Peak Area
Integration Time: 6.0 sec
BOC Time: 5 sec BOC = Background Offset
Correction. Zeeman Graphite Furnace
(Perkin-Elmer Model HGA-600)

WAC 296-62-07449 (Cont.)

Step	Ramp Time (sec)	Hold Time (sec)	Temp (°C)	Argon Flow (mL/min)	Read (sec)
1) Predry	5	10	90	300	--
2) Dry	30	10	140	300	--
3) Char	10	20	900	300	--
4) Cool Down	1	8	30	300	--
5) Atomize	0	5	1600	0	-1
6) Burnout	1	8	2500	300	--

[Statutory Authority: Chapter 49.17 RCW. 93-21-075 (Order 93-06), § 296-62-07449, filed 10/20/93, effective 12/1/93; 93-07-044 (Order 93-01), § 296-62-07449, filed 3/13/93, effective 4/27/93.]

WAC 296-62-07451 A short description of Appendix F to 29 CFR 1910.1027--Nonmandatory protocol for biological monitoring. Appendix F is not included in this standard due to limited employer/employee application. The following is a brief synopsis of the content of Appendix F to 29 CFR 1910.1027, Cadmium.

(1) The medical monitoring program for cadmium requires that blood and urine samples must be collected at defined intervals from workers by physicians responsible for medical monitoring. These samples are sent to commercial laboratories that perform the required analyses and report results of these analyses to the responsible physicians. To ensure the accuracy and reliability of these laboratory analyses, the laboratories to which samples are submitted should participate in an ongoing and efficacious proficiency testing program.

(2) This nonmandatory protocol is intended to provide guidelines and recommendations for physicians and laboratories to improve the accuracy and reliability of the procedures used to analyze the biological samples collected as part of the medical monitoring program for cadmium. This protocol provides procedures for characterizing and maintaining the quality of analytic results derived from the analyses of cadmium in blood (CDB), cadmium in urine (CDU), and beta-2-microglobulin in urine (B2MU) by commercial laboratories. Laboratories conforming to the provisions of this nonmandatory protocol shall be known as "participating laboratories."

(3) This protocol describes procedures that may be used by the responsible physicians to identify laboratories most likely to be proficient in the analysis of samples used in the biological monitoring of cadmium. It also provides procedures for record keeping and reporting by laboratories participating in proficiency testing programs, and recommendations to assist these physicians in interpreting analytical results determined by participating laboratories.

(4) For those needing Appendix F, 29 CFR 1910.1027, in its entirety, a copy may be obtained by request to:

Department of Labor and Industries
Division of Industrial Safety and Health
Standards and Information
Post Office Box 44620
Olympia, Washington 98504-4620
or telephone (360) 956-5527

[Statutory Authority: Chapter 49.17 RCW. 93-07-044 (Order 93-01), § 296-62-07451, filed 3/13/93, effective 4/27/93.]